Midwest Vegetable Production Guide for Commercial Growers

2015

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University of Illinois Extension
C1373-15

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Changes will be made throughout the year as they are received.

Abbreviations Used in This Guide	
PHI	pre-harvest interval — the minimum allowable time in days between the latest pesticide application and crop harvest
AI	active ingredient
COC	crop oil concentrate
D	dust formulation
DF, DG	dry flowable or water dispersible granule formulation
E, EC	emulsifiable concentrate
F	flowable formulation
G	granular formulation
L, LC	liquid concentrate formulation
NIS	nonionic surfactant
REI	re-entry interval
RUP	restricted use pesticide
SC	suspension concentrate
W, WP	wettable powder formulation

Cover photos: These watermelon vines have been manually turned into the row so that the area between rows can be cultivated for weed control. Soon after this photo was taken, the vines were allowed to grow into the row middles for the remainder of the season.

Insect, disease, and weed control recommendations in this publication are valid only for 2015. If registration for any of the chemicals suggested is changed during the year since the time of publication (December 2014), we will inform all area and county Extension staff. If in doubt about the use of any chemical, check with your Extension agent or chemical company representative.

The information presented in this publication is believed to be accurate but is in no way guaranteed. The authors, reviewers, publishers, and their institutions assume no liability in connection with any use for the products discussed and make no warranty (expressed or implied) in that respect. Nor can it be assumed that all safety measures are indicated herein or that additional measures may be required. The user, therefore, must assume full responsibility, both as to persons and as to property, for the use of these materials including any that might be covered by patent. Always refer to the pesticide labels before each application. If the label information is different than the information presented in this guide, always follow the product label.

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Photos by the contributors, Brian Christie, Mike Kerper, John Obermeyer, and Elizabeth Wuerffel

Contents

Statement of Purpose

The management practices, products, and cultivars discussed in this publication are the research- and experience-based recommendations of the institutions associated with the contributing editors and authors. These recommendations are not exhaustive and other practices and products not mentioned in this guide might also be effective. *Read and follow label instructions before using any pesticide product.*

What's New in 2015?

Highlights of Changes in This Edition

New and Revised Sections

- Table 33: Common and Scientific Vegetable Pest Names (page 74) lists the common and scientific names of the pests listed in this guide.
- Table 18: Sanitizers Approved for Wash or Process Water (page 46) lists federally approved sanitizers for vegetables.
- Table 12: Yields of Vegetable Crops (page 37) has been updated.

Disease Management

- White rust has been added to the Cole Crops and Brassica Leafy Greens chapter.
- Bacterial fruit botch recommendations have been revised in the Cucurbit Crops chapter.
- Merivon® has been added to the Cole Crops and Brassica Leafy Greens, Cucurbit Crops, and Dry Bulb and Green Bunching Onion, Garlic, and Leek chapters.
- Priaxor® has been added to the Fruiting Vegetables chapter.
- Aproach® has been added to the Legumes chapter.

Weed Management

- Command 3ME® is now labeled for use on broccoli, cauliflower, Brussels sprouts (see the Cole Crops chapter), and rhubarb.
- League ® is now labeled for use in pepper, tomato, potato, cantaloupe, and watermelon. The active ingredient is imazosulfuron, an ALS-inhibiting herbicide. This material has pre- and postemergent activity against yellow nutsedge, hairy galinsoga, purslane, and pigweeds, and postemergent activity against morningglory.

Insect Management

- Azera® was added to the Cole Crops and Brassica Leafy Greens and Cucurbit Crops chapters.
- Beleaf 50SG® was added to the Cole Crops and Brassica Leafy Greens, Cucurbit Crops, Fruiting Vegetables, Potato, and Sweet Potato chapters..
- Exirel® was added to the Cole Crops and Brassica Leafy Greens, Cucurbit Crops, Fruiting Vegetables, and Dry Bulb and Green Bunching Onion, Garlic, and Leek chapters.
- Torac® was added to the Cole Crops and Brassica Leafy Greens and Potato chapters.
- Transform® was added to the Legumes and Potato chapters.
- Zeal® was added to the Mint and Okra chapters.

Watermelon seedlings being grown as transplants in a commercial greenhouse.

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The University of Illinois publishes *Illinois Fruit and Vegetable News*, a newsletter that covers production practices and insect, disease, and weed management. It is available at ipm.illinois.edu/ifvn. For information or to order, contact Rick Weinzierl, Department of Crop Sciences, University of Illinois, 1102 S. Goodwin Ave., Urbana, IL 61801; (217) 244-2126; or weinzier@illinois.edu. Fact Sheets about vegetable and fruit crops from the University of Illinois are available at extension.cropsci.illinois.edu/fruitveg.

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Purdue Extension Vegetable Crops Hotline

Purdue Extension issues a bi-weekly vegetable newsletter to growers throughout the vegetable growing season at a nominal cost. This newsletter provides timely information on disease and insect activity and management, as well as cultural and post-harvest information. To subscribe, send your name, address, and phone number, along with a check for $15, payable to Purdue University to:

Elizabeth Maynard
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Subscribers to the hotline also will receive the *Vegetable Crops Hotline Bulletin,* and faxed or emailed updates, at no extra cost. Please indicate email address or fax number. The hotline also is available free at www.btny.purdue.edu/pubs/vegcrop.

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The Ohio State University publishes the *VegNet* newsletter nearly weekly during the season and less frequently off-season. The newsletter covers production practices and insect, disease, and weed management. It is available free at vegnet.osu.edu. For information or to order, contact Jim Jasinski, Department of Entomology, Ohio State University; (937) 484-1526; or jasinski.4@osu.edu.

Soil Testing

Soil tests aid vegetable growers with their crop management, rotation, and fertilizer application programs. Soil tests are most useful when growers keep accurate records for each field that include the amount of fertilizers and other soil amendments they applied, crop yields, and rotations. These records allow growers to discover trends in soil fertility and crop response to applied fertilizers over several years.

Efficient vegetable production relies on growers adjusting their lime and fertilizer applications to their soils' existing fertility levels. Growers can increase their net returns if they maintain proper soil fertility, which can reduce crop losses from physiological disorders. Applying nutrients based on crop needs and existing soil levels also reduces the movement of nutrients into groundwater and surface waters.

Take soil samples at the same time each year, preferably in the fall or early spring. Soil pH varies seasonally, so comparing winter and summer samples is difficult. A typical soil test for plants usually determines pH, lime index (also called buffer pH), available Bray P1 phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity. It also includes and the percent base saturation of Ca, Mg, and K.

In addition to the routine pH test, growers should test soils that are susceptible to large variations in soil pH for salt pH. The salt pH provides a more accurate estimate of the true acidity in these soil types by simulating the effects of fertilizer salts on soil pH.

There are also tests to determine organic matter and other nutrients, including sulfur (S), manganese (Mn), boron (B), and zinc (Zn). Some labs test for microbial activity and water-soluble carbon, which can predict the release of nitrogen and phosphorus from organic sources.

Your land-grant university or extension service can provide you with a list of soil testing labs in your area.

Soilless Growing Media

Test soilless growing media used in transplant or crop production for pH and total soluble salts before using it. Request a test specifically for "soilless media" from the lab. If the crop will be grown in soilless media more than a month, regularly test the media or plant tissue to catch any nutrient imbalances that may affect crop growth and yield.

Interpretation of Standard Soil Test Results

- **Soil pH** (sometimes called active soil acidity) is based on the pH scale, which measures the acidic or basic reaction of the soil. A pH less than 7 is acidic; a pH greater than 7 is alkaline. When soil pH is too low for good crop growth, adding lime will raise the pH. Natural processes and agricultural practices tend to lower pH over time, so it is important to measure it every year or two.
- **Lime index** (sometimes called "buffer pH") measures reserve soil acidity. The lime index is used to make limestone recommendations. It usually takes lime four to six months to correct soil acidity. Your land-grant university or extension service can provide you with liming recommendations specific your state.
- **Phosphorus** may be reported as P (phosphorus) or P_2O_5 (phosphate). The units for P and other nutrient values may be given as parts per million (ppm) or pounds per acre. The value is an estimate of the amount of phosophorus in the soil that the plant can use for growth. Applying P_2O_5 fertilizer at 100 pounds per acre will increase the soil P test level by about 10 pounds per acre.
- **Potassium** may be reported as K (potassium) or K_2O (potash). The test value estimates the amount of K available per acre. About 50 percent of the potassium applied in fertilizers is fixed in the soil and is not immediately available to plants — this can vary by soil type and clay content. Soil K declines due crop removal, leaching, and soil erosion.
- **Calcium (Ca) and magnesium (Mg)** soil test values represent the amount of Ca and Mg available in the soil. Ca and Mg values generally are low when soils are acidic. Levels are usually sufficient when pH and the lime test index are at proper levels.

- **Cation exchange capacity (CEC)** is a measure of the soil's ability to hold exchangeable cations such as hydrogen (H), Ca, Mg, K, sodium (Na), iron (Fe), and aluminum (Al). CEC is measured in terms of milliequivalents (meq) per 100 grams of soil. Soil type and soil organic matter determine CEC. Clay-, silt- and loam-type soils generally have a higher CEC than sandy soils because they have many more exchange sites to hold cations. High-CEC soils generally hold nutrients better than low-CEC soils. Low-CEC also lose smaller amounts of nutrients due to leaching.

  Here are the typical CEC ranges of various soil types:

Soil Texture	CEC Range
Sands	5-15
Silts	8-30
Clays	25-50
Organic soils	50+

- **Base saturation** is the percentage of the total CEC occupied by basic cations such as Ca, Mg, and K. Base saturation is related to soil pH and soil fertility. On acid soils, the percent base saturation of Ca and Mg is low. The saturation of the different cations is important because plants take up some cations more easily than others. The base saturation for Ca should be 60 percent or more; Mg should range between 10 and 15 percent; K should range from 1 to 5 percent. Excess levels of one cation can reduce the uptake of another. Some soil scientists believe that there should be specific Ca:Mg ratios and Mg:K ratios (2:1). Most horticulturists believe that if base saturation levels are at the minimum levels suggested here, then it is not important to maintain specific proportions or ratios.

Macronutrients or Primary Nutrients

Nitrogen (N), phosphorus (P), and potassium (K) are macronutrients or primary nutrients and most commonly applied in fertilizers for field vegetable production. Plant nutrient recommendations are often given as pounds of N, pounds of phosphate (P_2O_5) and pounds of potash (K_2O) per acre.

It is up to growers to figure how much fertilizer or product they must apply to meet the suggested recommendations. This can be tricky, because growers may need more than one kind of fertilizer product to meet the recommendations.

Fertilizer products are required to list the percent N, P_2O_5, and K_2O equivalent they contain — and the products are listed in the order: N-P-K. For example, a fertilizer labled 10-10-10 contains the equivalent of 10 percent N, 10 percent P_2O_5, and 10 percent K_2O. So a pound of this fertilizer would contain 0.1 pound each of N, P_2O_5, and K_2O.Urea labeled 46-0-0 contains 46 percent N, 0 percent P_2O_5, and 0 percent K_2O. Potassium chloride (muriate of potash) labeled 0-0-60 contains 0 percent N, 0 percent P_2O_5, and 60 percent K_2O. Organic fertilizers are also labeled this way — a 3-2-2 product contains 3 percent N, 2 percent P_2O_5, and 2 percent K_2O. It's important to note that some of the N and P in organic fertilizers require warm, moist soil and microbial activity before it is available to plants.

Let's say a nutrient recommendation calls for 100 pounds of N and 100 pounds of K_2O per acre.

A grower could meet that recommendation by using 217 pounds of urea (217 pounds of urea X 0.46 N = 100 pounds of N) and 167 pounds of potassium chloride (167 pounds of potassium chloride X 0.60 K_2O = 100 pounds of K_2O).

A grower could also meet that recommendation by using 1,000 pounds of premixed 10-10-10 fertilizer (1,000 pounds of fertilizer X 0.10 N = 100 pounds of N; 1,000 pounds of fertilizer X 0.10 K_2O = 100 pounds of K_2O). But that same fertilizer would also supply 100 pounds of P_2O_5 that is not needed. So using such a fertilizer could be a waste of money and could pollute surface or ground water.

If you choose a premixed fertilizer, select the ratio of nutrients that comes closest to the amount of recommended nutrients. It is not necessary to be exact as long as any differences are reasonable. If you can't get to the recommended nutrient application using premixed fertilizers, it is fine to first make a base application using a standard fertilizer ratio, and then apply individual elements to reach the recommended nutrient levels.

For example, you can supply extra N with urea or urea ammonium nitrate solution; you can supply extra K with muriate of potash. Custom-blended fertilizers can be made to almost any desired ratio.

Nitrogen (N)

Standard soil tests aren't very useful for predicting how much N fertilizer you need to apply to optimize yield and qualilty. N fertilizer recommendations account for the soil type, amount of organic matter in the soil, field history, and crop. The recommendations in this guide are based on data from relevant field trials. Adjust these recommendations according to experience, soil type, cropping history, additions of organic matter, and crop culture system.

For example, suppose your vegetable crop is following soybeans, alfalfa, or a grass-legume hay crop. If your soils have more than 3 percent organic matter, you may not need to add any sidedressed N. If your soils that have less than 3 percent organic matter, then half the total N can be applied preplant and the other half sidedressed early in the crop growth cycle.

Now suppose your vegetable crop is following corn, rye, oats, wheat, or a previous vegetable crop. There may be no residual soil N available, so the crop may benefit from additional sidedress N. It may be useful to test the soil for nitrate-N shortly before sidedressing to assess whether the crop will benefit from the application.

Phosphorus (P)

P recommendations for vegetables are based on the soil test value, the type of crop, and estimates of crop removal. On mineral soils, most vegetables will benefit from P fertilization if the soil test is less than 35-40 ppm P using the Bray-Kurtz P1 extraction method.

If the soil test on a mineral soil is more than 80 ppm P, then no additional P is recommended for most vegetables. P does not move readily in the soil and applied P easily reacts with soil minerals so that it is unavailable to the plant. That's why P fertilizer is applied in bands near the crop when possible, and starter solutions that are high in P are recommended for transplants.

Potassium (K)

K recommendations for vegetables are based on the soil test value, the soil CEC, the type of crop, and estimates of crop removal.

Vegetables usually benefit from K fertilization if the soil test is:

- Less than 85 ppm K on a soil with low CEC (4 meq/100 g).
- Less than 115 ppm K on a soil with medium CEC (16 meq/100 g).

The maximum annual K recommendation for most vegteables is 300 pounds of K_2O per acre. K fertilization is not usually recommended if the soil test is more than 135 ppm K on a soil with low CEC, or more than 165 ppm K on a soil with medium CEC.

Petiole Sap Testing

Petiole sap analysis is a rapid diagnostic method you can use to monitor nutrient levels in a variety of vegetable crops during the growing season. Sap testing is most common for checking N, although you can also monitor K levels. Sap tests do not supply any information you cannot get through standard plant tissue testing.

But sap tests can be done on the farm, are less expensive, and eliminate the delay between the time a sample is collected and laboratory results are available. These factors can be critically important when you suspect a nutrient deficiency, or you are preparing to fertigate or to make a sidedress fertilizer application and you want to know what rate to use. Plant nutrient levels can change quickly, especially during rapid growth phases.

Sap tests measure the nutrient concentrations in plant sap that has been squeezed from leaf petioles. Two of the most popular sap-testing equipment are Horiba® and Cardy® meters. The meters are hand-held, battery-operated, and have ion-selective electrodes for testing nitrate-nitrogen or potassium. They have flat sensors that require a small sample volume and give a direct readout of concentration.

Sufficient nutrient levels for many vegetable crops have been developed in Florida and California. On-farm surveys and research on a few crops, including

pepper, tomato, and cantaloupe, have found those recommendations useful in the Midwest as well. Midwest growers should consider the values from Florida in Table 1 as initial guidelines. Keep records of sap tests and fertilizer applications, and adapt the Florida guidelines as necessary to fit your conditions and management system.

The advantages of petiole sap tests are that they are relatively simple, give immediate results, and are particularly useful for making timely adjustments in fertilizer application rates when using fertigation. They are designed as an on-farm crop management tool and are meant to supplement, not replace, standard soil testing and nutrient management programs. Sap tests are not as precise as laboratory analyses, but if used carefully, they are reasonably accurate and sufficiently precise to distinguish between adequate and deficient plant nutrient levels.

In short, they are accurate enough to help growers make decisions that can increase the efficiency of their fertilizer appliations. Growers may improve yield or quality by more closely matching nutrient rates and timing with plant needs. They may also reduce or eliminate unnecessary fertilizer applications, which can save money and reduce the potential harm to the environment from leaching or runoff.

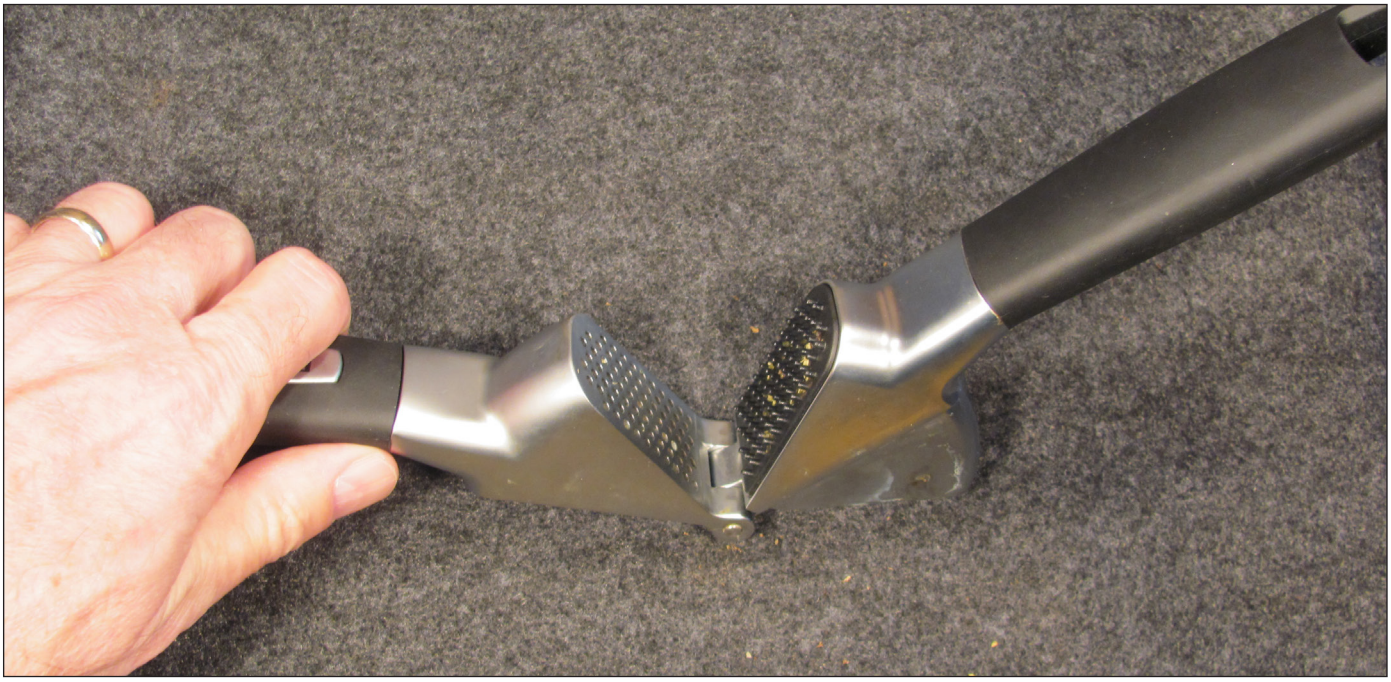
Procedures for Sap Testing

To collect a sample for sap testing:

- Obtain a representative sample.
- Sample at a consistent time of day — sampling time may affect N results.
- Sample the uppermost, recently matured leaves.
- Remove the petiole or "leafstalk."
- Collect about 25-30 petioles per sample.
- Avoid damaged, diseased leaves.
- Collect separate samples for different:
    - Varieties, planting dates, and areas with deficiency symptoms.
    - Cultural practices, soil types, and irrigation sections.

After collecting a sample for sap testing, follow these handling guidelines:

- Do not allow petioles to lose moisture after picking.
- Strip leaf blades from petioles soon after picking.
- Place samples in closed plastic bags and store them in a cooler on ice.
- Do not store expressed sap for long periods (unless frozen).
- You can store petioles for 1 or 2 hours at moderate temperatures, somewhat longer on ice.



A garlic press may be used to extract sap for petiole testing.

Table 1: Guidelines for Plant Leaf Petiole Fresh Sap Nitrate-N and K Testing[1]

Crop	Crop Developmental Stage	Fresh Petiole Sap Concentration (ppm)	
		NO_3-N	K
Broccoli and Collard	Six-leaf stage	800-1,000	NR
	One week prior to first harvest	500-800	
	First harvest	300-500	
Cantaloupe	First blossom	1,000-1,200	NR
	Fruit 2 inches long	800-1,000	
	First harvest	700-800	
Cucumber	First blossom	800-1,000	NR
	Fruit 3 inches long	600-800	
	First harvest	400-600	
Eggplant	First fruit 2 inches long	1,200-1,600	4,500-5,000
	First harvest	1,000-1,200	4,000-4,500
	Mid-harvest	800-1,000	3,500-4,000
Pepper	First flower buds	1,400-1,600	3,200-3,500
	First open flowers	1,400-1,600	3,000-3,200
	Fruit half-grown	1,200-1,400	3,000-3,200
	First harvest	800-1,000	2,400-3,000
	Second harvest	500-800	2,000-2,400
Potato	Plants 8 inches tall	1,200-1,400	4,500-5,000
	First open flowers	1,000-1,400	4,500-5,000
	50% flowers open	1,000-1,200	4,000-4,500
	100% flowers open	900-1,200	3,500-4,000
	Tops falling over	600-900	2,500-3,000
Squash	First blossom	900-1,000	NR
	First harvest	800-900	
Tomato *(field)*	First buds	1,000-1,200	3,500-4,000
	First open flowers	600-800	3,500-4,000
	Fruit 1 inch in diameter	400-600	3,000-3,500
	Fruit 2 inches in diameter	400-600	3,000-3,500
	First harvest	300-400	2,500-3,000
	Second harvest	200-400	2,000-2,500
Tomato *(greenhouse)*	Transplant to second fruit cluster	1,000-1,200	4,500-5,000
	Second cluster to fifth fruit cluster	800-1,000	4,000-5,000
	Harvest season	700-900	3,500-4,000
Watermelon	Vines 6 inches long	1,200-1,500	4,000-5,000
	Fruit 2 inches long	1000-1,200	4,000-5,000
	Fruit half mature	800-1,000	3,500-4,000
	First harvest	600-800	3,000-3,500

[1]NR=no recommendation.

Source: George Hochmuth, *Plant Petiole Sap Testing*, University of Florida Cooperative Extension Service Circular 1144, 1994.

To analyze and interpret sap test results:

- Calibrate the meter every day before use.
- Warm petioles to room temperature before pressing and analyzing them.
- Cut petioles into ¼-inch pieces with a clean knife on a clean cutting board and mix the pieces well.
- Squeeze sap from a subsample of petiole pieces onto the electrode with a garlic press.
- Compare results with previous tests — are levels increasing, decreasing, or staying about the same?
- Compare results with Florida sufficiency levels in the table below.
- Adjust fertigation or side-dress fertilizer rates based on sap-test results.

Cardy meters for nitrate-N and K petiole sap testing are available in the United States through two sources: Spectrum Technologies (www.specmeters.com) and Gempler's (www.gemplers.com).

Sap nitrate-N and K recommendations are available in:

> *Plant Petiole Sap Testing: Guide for Vegetable Crops* (University of Florida Cooperative Extension Service Circular 1144, edis.ifas.ufl.edu/cv004).

Fertilizer and the Environment

Both natural (manures, composts, green manures) and synthetic N sources can be lost from fields, which can pollute water and increase greenhouse gasses that contribute to climate change. Similarly, natural and synthetic sources of P can move out of cropped areas and pollute waterways. With proper fertilizer management, vegetable producers can minimize environmental impacts and improve fertilizer use efficiency. Growers should know their crops, account for the nutrient values of all soil amendments, and test soils and plants to support their fertilizer decisions.

Split N applications — applying some N before planting and sidedressing the rest during the season — are generally more efficient than complete preplant applications. However, split applications require growers to pay attention to crop growth and sidedress at the appropriate times: before crops are stressed, and early enough to allow crops to mature.

Banding P at planting (with or without some P being broadcast/incorporated), is generally more efficient than broadcasting all P. Sidedressing P is not recommended because it is not mobile in soils.

Generally, K and the minor elements do not contribute significantly to groundwater pollution, but growers should manage them properly to minimize costs and maximize efficiency.

Minimizing soil erosion, timing irrigation properly, and avoiding excess irrigation will also improve fertilizer use efficiency and reduce losses from the field.

Fertilizer Application Methods

Fertilizer application timing and methods vary from farm-to-farm depending on cultural practices and equipment. This section outlines common practices of efficient fertilizer placement and utilization. These practices can be modified to suit particular situations.

Usually, growers can apply at preplant and disk into the soil 50-60 percent of the recommended N and all of the P and K fertilizer. This is especially true when the rates of a complete fertilizer will require more than 400 pounds per acre.

We recommend band application for many direct-seeded vegetable crops. This technique applies a concentrated line of fertilizer 2 inches to the side and 2 inches below the seed furrow. This is an efficient way to apply fertilizer, and much of the P and K fertilizer can be applied this way. However, do not make banded fertilizer applications exceeding 80 pounds per acre of N plus K — this can injure seed.

For crops grown on plastic mulch (with or without a raised bed) growers may apply fertilizer just to the bed area. As with broadcast applications, growers can apply a portion of the recommended N, and all of the P and K before planting. If N will be supplied through fertigation during the season, apply only 20 to 50 percent of the total N before planting. Apply the remaining N with regular drip irrigation at 5 to 10 pounds of N per week until the total recommended for the season has been applied.

If you apply only part of the recommended N before planting, sidedress additional N when the plants are still young, or apply N through fertigation before and during the period of rapid crop growth. Early sidedress applications are especially important with crops such as sweet corn, broccoli, and cabbage. The total N applied during the growing season (broadcast, plus banded,

plus transplant starter, plus sidedressed, plus fertigated) should equal the recommended N rate. Applying more than the recommended rate of N may be necessary when there are leaching rains.

Transplanted crops often respond to a small amount of water-soluble fertilizer in the transplanting water. Special fertilizer grades (such as 14-28-14, 10-52-10, 23-21-17) are used at a rate of 3 pounds per 50 gallons of water. The high-P liquid 10-34-0 can also be used at the rate of 2 quarts per 50 gallons of water. Apply starter solutions at 8 ounces per plant. If dry weather is prevalent, irrigate after setting the plants.

Liming and Soil pH

Soil pH describes whether the soil solution is acidic or alkaline. The native pH of Midwest soils varies from quite acidic (pH 5.0 or lower) to quite alkaline (pH 7.5 or higher). Most vegetable crops prefer a pH range of 6.0-6.8 on mineral soils. On muck soils, a pH of 5.5-5.8 is considered adequate. Vegetables grown under acid soil conditions lack vigor and yield poorly. Acid soils restrict the uptake of nutrients such as P and K. Acid soils also make elements such as aluminum (Al) and Mn more available to plants so that the plant may absorb enough to be toxic to the plant. Under severe conditions, visible foliage injury can result from Mg deficiency and/or Mn toxicity. Physiological disorders such as blossom end rot are more common on acid soils. In contrast, when soil pH is high, Mn, B, iron (Fe), and certain other micronutrients become less available for plant uptake. Deficiencies of these micronutrients are most likely to occur on mineral soils with pH greater than 7.4.

Lime neutralizes soil acidity and supplies Ca and Mg, elements necessary for plant growth. A soil test determines how much lime you need (see Soil Testing, page 10). Liming may be necessary every few years because soil pH tends to decline over time. The decline is caused by synthetic N fertilizers, the crop's removal of Ca, and the leaching of Ca and Mg by rain.

Soil pH and Plant Nutrients

Nitrogen (N)

Plants can take up N in the form of ammonium (NH_4^+) or nitrate (NO_3^-). In the soil, ammonium is converted into nitrate, and vice versa, by a particular set of microbes. When soil pH is near neutral (pH 7), and the soil is moist and warm, the microbial conversion of ammonium to nitrate (nitrification) is rapid, and crops generally take up nitrate. In acid soils (pH lower than 6), nitrification is slow, and plants will take up a higher percentage of N as ammonium.

Soil pH also plays an important role in N loss due to volatization. Volatilization occurs when N compounds turn to gaseous forms (ammonia, nitrous oxides, N gas) and evaporate into the air. Ammonium in the soil solution exists in equilibrium with ammonia gas (NH_3). The amount of each compound depends to a large extent on the soil pH. At lower pH, there is more ammonium and less ammonia gas. At pH 7, the equilibrium condition is 99 percent ammonium and 1 percent ammonia. At pH 8, the equilibrium is about 90 percent ammonium and 10 percent ammonia gas.

Volatilization from N fertilizers that contribute ammonium to the soil (such as urea) is likely to be high at higher soil pH levels. However, depending on soil temperature and moisture, volatilization can be significant at lower soil pH levels, too, especially if the soil is dry and the fertilizer is not incorporated. To minimize volatilization, apply N in just the quantities plants need during the growing season, incorporate it into the soil, and use slow-release sources when possible.

Soil pH is also an important factor in the N nutrition of legumes. Plants in this family are able to fix N from the soil with the help of several Genera of soil bacteria known collectively as *Rhizobia.* As soils become more acidic, Rhizobia decline in activity, fixing less N.

Phosphorus (P)

Plants absorb P from the soil solution in the form of soluble phosphates. At any time, the amount of P in solution is usually extremely low — often less than 1 pound per acre — because P joins with other elements in the soil to form stable minerals.

The type of mineral that gets formed in the soil depends on the soil's pH. In alkaline soils, P in fertilizers such as mono-ammonium phosphate (11-55-0) usually reacts with Ca to form calcium phosphate minerals. The P in calcium phosphate minerals is not available to plants, but as plants remove P from the soil solution, the minerals gradually dissolve to replenish the supply of P in the soil solution. Greenhouse and field research has shown that more than 90 percent of the fertilizer P tied up this year in calcium phosphate minerals will be available to crops in future

In acid soils, P usually reacts with Al and Fe, instead of Ca. Aluminum and iron phosphates do not dissolve as readily as calcium phosphates, so in acid soils, applied P tends to be tied up more than in alkaline soils.

Potassium (K)

In soils with certain types of clay, K is fixed at specific sites between clay layers. This tends to be reduced under acid conditions, presumably because Al occupies the binding sites that would otherwise trap K. Because of this, one might think that raising the pH by liming would reduce the availability of K. However, this is not the case — at least in the short term. Liming increases K availability, probably because Ca displaces K on exchange sites.

Sulfur (S)

Plants absorb sulfur as sulfate (SO_4^{2-}). Sulfate is little affected by soil pH.

Micronutrients

Micronutrients are elements plants need in very small amounts. The availability of the micronutrients — Mn, Fe, copper (Cu), Zn, and B — decreases as soil pH increases. The exact mechanisms responsible for reducing availability differ for each nutrient. Micronutrient deficiencies are more likely at high pH, and toxicities are more likely at low pH.

The availability of molybdenum (Mo) is reduced under acid conditions. Mo deficiency is more likely to occur in acid soils.

Summary

Soil pH plays an important role in nutrient availability. If soil pH is too high or too low, it is difficult to properly balance the nutrients required for good crop growth. Manage soil to keep its pH in the acceptable range. Be aware of soil pH and its influence on nutrient availability as you make a nutrient management plan and during crop production.

Types of Lime

Several types of lime that may be used to manage soil pH and/or Ca and Mg are described below. After each discussion, the percentage of CaO and MgO in a typical batch of lime is given.

Calcitic lime (also called high-calcium lime — 50-56% CaO, 1-4% MgO) is the most soluble form and is the preferred type when soil Ca is low and soil Mg is high. It generally reacts the fastest and is the most common form available in some areas.

Magnesian lime (also called hi-mag lime — 32-42% CaO, 5-15% MgO) is intermediate in solubility and is the preferred type when pH, Ca, and Mg are low. The continued use of high-Mg liming materials increases the base saturation of Mg and decreases Ca saturation, which may result in Ca deficiencies during stress periods.

Dolomitic lime (30% CaO, 20% MgO) is the preferred type when Mg is particularly low. Dolomitic lime is the least soluble of the materials.

Hydrated lime (60% CaO, 12% MgO) reacts most rapidly with the soil, but unlike the ground limestones described above, it does not continue to provide liming activity over a period of years. Hydrated lime is caustic to humans and plants, and applicators must take care not to burn plants. Use hydrated lime only in emergencies when rapid changes in soil pH are needed.

Gypsum is not a liming material and does not affect soil pH. It is a crude calcium sulfate product consisting chiefly of calcium sulfate with combined water ($CaSO_4$ $2H_2O$). Although gypsum is not capable of neutralizing soil acidity, it is a source of calcium and sulfur.

Fluid lime is a suspension of finely ground limestone in water, and may contain other dispersing agents. Finely ground limestone reacts with soil more quickly than normal limestone. In fluid lime, 100 percent of the liming material must pass through a 100-mesh screen, and nearly 80 to 90 percent must pass through an even smaller 200-mesh screen. The principles of effectiveness of ground agricultural lime also apply to fine or fluid lime. Lime suspensions do not possess any special capabilities compared with conventional agricultural lime that contains a high degree of 60-mesh or finer particles.

Pelletized lime, or pell-lime, is finely ground lime that has been formed into pellets for easy application. Because it is finely ground, it will react quickly in the soil. Unlike regular ag lime, it will not provide residual liming activity over a few years.

Lime Recommendations

Fields usually require lime every few years because Ca and Mg are removed in harvested portions of the crop, leached out of surface soil by rainfall, and lost from the field when soil erodes. Lime is also needed to neutralize acidity produced by acid-forming fertilizers.

Growers sometimes need to add lime to correct subsoil acidity. In that case, apply enough lime to bring the surface soil to pH 6.8. The subsoil pH will increase only if you maintain the surface pH near 6.5 or more. Over time, rain will leach the Ca and Mg into the subsoil, raising its pH. Because this downward movement takes several years, the sooner the lime is applied, the better.

In most cases, make split applications when the recommendation is more than 4 tons per acre. This will achieve a more thorough mixing with the acidic soil. Apply half the lime before plowing and half before soil fitting. For best results, apply the lime at least six months before seeding a legume.

If you have a recommendation for a maintenance application of 2 tons per acre or less, you can apply it at any time in the cropping sequence.

Secondary and Micronutrients

Secondary plant nutrients include Ca, Mg, and S. Micronutrients include boron (B), chlorine (Ch), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). Of these 11 nutrients, those most likely to be lacking in Midwest soils used for vegetable production are Ca, Mg, B and Mn. S and Zn may also be of concern in some areas.

Ca and Mg usually are deficient on acid soils. Adding calcitic or dolomitic lime solves most Ca and Mg deficiency problems (see Liming and Soil pH, page 16). When Ca is deficient and there is no need to increase soil pH, you may use gypsum as a source of Ca. Similarly, you can add Mg without affecting pH by using Epsom salts (magnesium sulfate, 10 percent Mg), sul-po-mag (11 percent Mg), or finely ground magnesium oxide (e.g. MAGOX®, 58 percent Mg).

If a soil test shows low Mg (less than 50 ppm in Minnesota or less than 40 ppm in other states), apply Mg at 100 pounds per acre broadcast or 20 pounds per acre in the row. If a soil test shows medium Mg (51-100 ppm in Minnesota or 40-69 ppm in other states) apply Mg at 50 pounds per acre broadcast or 10 pounds per acre in the row. If a soil test shows high Mg, no application is necessary. You can make foliar sprays of Epsom salts at the rate of 10 to 15 pounds in a least 30 gallons per acre to temporarily solve Mg deficiencies during the growing season.

Mn deficiency is common in some areas. Mn deficiency occurs primarily on lakebed and fine-textured, dark-colored soils with high pH. Cool, wet conditions tend to intensify Mn deficiency. Beans, beets, onions, spinach, and tomatoes have high requirements, but deficiencies also are reported for cucumbers, peppers, and turnips. Applying manganese sulfate at the rate of 2 to 4 pounds per 100 gallons per acre to eliminate deficiency problems observed during the growing season. Fungicides containing Mn can also help correct deficiencies.

B leaches readily, so responsive crops often need annual applications on sandy loam, loamy sand, sandy, and muck soils. Deficiency symptoms include browning on cauliflower heads, cracked stems on celery, blackheart on beet, and internal browning on turnip.

Broccoli, cautiflower, celery, beet, turnip, and rutabaga are likely to respond to B applications of 3 to 4 pounds per acre when soil levels are low. Cabbage, carrot, lettuce, parsnip, radish, spinach, and tomato show a medium response and usually benefit from 1 to 2 pounds of B per acre.

Bean, peas, and cucumber are sensitive to B, so do not apply it to these crops.

You can add B to the soil with Borax® (which contains 10.6 percent B) or Solubor® (which contains 20.5 percent B). B applications are most effective if applied with the fertilizer at preplant or at the time of transplanting. Mid- or late season foliar applications are not as effective as early granular or foliar applications. It is important not to exceed recommended B rates to avoid toxicity in subsequent B-sensitive crops. Carryover is most likely after a dry fall and winter.

Other micronutrient deficiencies are rare in field-grown vegetable crops in this region.

Chemigation Management

Chemigation is the process of applying an agricultural chemical (pesticide or fertilizer) to the soil or plant surface through an irrigation system. Depending on the type of agricultural chemical, chemigation may be referred to as fertigation, insectigation, fungigation, etc.

For chemigation applications, you can only use pesticides that display EPA approval for such applications on the label. Each chemigation and irrigation system also must use the safety equipment specified on the EPA label as well as any equipment required in your state. Some states also may require a system or operator permit before you can apply any product with chemigation.

Chemigation can be an effective application option for some labeled pesticides if the irrigation system can apply the chemical/water solution uniformly over the target area with the correct water depth. Some pesticides work best with less than 0.25 inch of water per application. Most late-model center pivot and linear move systems provide adequate distribution but some may not be able to apply a small enough volume of water. Solid set sprinkler systems may be effective for some pesticides but require close timing of chemical movements to get complete and uniform coverage of the field. Traveling gun and hand move systems do not provide water distribution that has high uniformity and are not recommended. Product labels provide more information about appropriate water application amounts and which irrigation systems are recommended.

If you do not have or maintain proper check valves and interlocks, the injected chemicals could backflow into the water source. EPA and many state regulations specify that each system must contain a reduced pressure zone (RPZ) backflow prevention valve or one or two independent check valves with low-pressure drains and vacuum relief valves between the irrigation water source and the point of chemical injection. Also, most regulations require a power interlock between the irrigation pump and the chemical injector unit, a low pressure shut down switch and a check valve on the chemical injection hose. For specific requirements, check with the appropriate local or state agency.

It is important to accurately calibrate the irrigation system and pesticide application rate. The chemigation operator must be aware of the irrigation system's application speed (acres per hour) for the chosen water application amount and the concentration of chemical solution to determine the rate of chemical injection.

More information about the special equipment, operations, and calibration is available in the University of Minnesota Extension Service bulletins, WW-06122, *Chemigation Safety Measures,* and WW-6118-GO, *Nitrogen Application with Irrigation Water,* available at www.extension.umn.edu.

Organic Matter and Cover Crops

Organic matter affects plant growth and frequently is referred to as the "glue" that holds soil particles together. It also promotes the development of soil aggregates, thus improving drainage, soil tilth, and soil structure. In sandy and sandy loam soils, organic matter improves water-holding capacity.

You can add organic matter to the soil by various methods using green manure crops, cover crops, crop residues, animal manures, mulches, and composts. Green manure crops include sweet clover, alfalfa, thickly sown field corn, and summer seedings of soybean. These crops generally are plowed under before they are mature. At this stage, the plants usually contain the greatest amount of N and other nutrients, plus an adequate amount of moisture for rapid decay. However, green manure crops also can be plowed under in the mature dry stage. At that stage, they do not decompose as readily and additional N may be needed to aid decomposition.

Typically, growers plant cover crops after harvest to protect the soil against erosion and usually turned the cover crops overthe following spring. Additional N may be needed to hasten the decomposition of the cover crop. This is especially important with rye, which should be plowed under before it is 18 inches tall.

Different cover crops frequently require special soil conditions for optimum growth. For example, alfalfa requires well-drained soils, while Ladino clover grows on poorly drained soils. Some crops, such as rye, have fibrous root systems, whereas others (sweet clover) have large taproots that can penetrate the soil to considerable depths. Whenever it is possible to use a mixture of these crops, the combination results in more organic matter to plow under.

Table 2 describes a few useful characteristics of cover crops that may be used for vegetable crops. For more information about cover crops, contact your sate extension service.

Table 2: Green Manure Crops for Vegetable Farms

Seeding Crop Number	Pounds/Bushel	Quantity of Seed per Acre (pounds)	Desirable Seeding Dates
Nonlegumes			
Rye	60	90-120 (alone) 90 (mixture)	Sept. 1-Nov. 10
Perennial or common ryegrass	24	15-20 (alone) 5-8 (mixture)	Aug. 1-Sept. 15
Sudangrass	40	20-30	May 15-July 1
Field corn	56	50-60	May 15-July 1
Winter barley	48	80-100	2-3 weeks before fly-safe date
Wheat	60	90-120	Hessian fly-safe date
Legumes			
Sweet clover	60	16-20 (alone) 10-12 (mixture)	March 1-April 15 July 15-Aug. 20
Red clover	60	10-15 (alone)	Feb. 1-April 1
Soybean	60	90-100	May 15-July 1
Alfalfa	60	12-18	March-April
Hairy vetch	60	15-20 (mixture)	Sept. 1-Nov. 1
Mixtures			
Rye/vetch		90/15-20	Sept. 1-Oct. 1
Ryegrass/sweet clover		5-8 12-15	July 15-Aug. 20
Sweet clover/orchardgrass		6-8	March 1-April 15

Animal Manures and Composts as Fertilizers

Animal manures and composts can provide significant nutrients to plants. The nutrient content of manures varies among animal species and within each species. Nutrients in composts can vary even more and depend on parent material and processing. Test manures and composts to determine the potential nutrient contributions and application rates. Avoid using composts made of unknown origin or parent material. Improperly made composts, be they of rural or urban origin, can contain heavy metals, inorganic debris, diseases, and insects that are unwelcome on your fields.

It is important to consider the timing of manure and compost applications. Fresh manure has potential to "burn" a crop because it often contains high levels of ammonia, and fresh or casually "aged" manure often contains human pathogens. For these reasons, it is rarely acceptable to apply fresh or "aged" manure to food crops while they are growing. Generally, a fall application is acceptable, ideally to a cover crop, and at least nine months before harvesting the next vegetable crop. Manure that has been properly composted and then protected from contamination is less likely to contain human pathogens and may be used closer to harvest if steps are taken to minimize contact with the food crop. Any use of manure or composts should follow current Good Agricultural Practices (GAPs) or the demands of a particular market, if more stringent. For guidance about current GAPs from the U.S. FDA, see www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm.

Transplant Production

Transplant production has replaced direct seeding for many vegetable crops. One of transplanting's primary advantages is earlier fruit production, allowing growers to capture better market conditions. In addition, the high cost of hybrid seed makes it desirable to use each seed as efficiently as possible. Transplanting also gives the crops a competitive advantage against weeds. This section addresses the special skills and knowledge required for successful transplant production.

Most growers use polyethylene-covered greenhouse structures to provide warmth and protection from the environment. Although cole crops do not need the more

moderating conditions a greenhouse provides, they can be grown in coldframes, lean-tos, or covered wagon beds.

The heater is one of the most critical features of a transplant greenhouse. Vegetable transplants must be kept at the appropriate temperatures. However, if heaters are improperly exhausted, the transplants can be stunted or deformed. To prevent heater fumes from returning into the greenhouse, chimneys should extend two feet above the ridge of the greenhouse.

There should be some provision for bringing fresh air into the greenhouse. Some heaters vent fresh air into the greenhouse every time the furnace operates. For others, a hole or holes should be cut in the greenhouse wall and fitted with tubes to feed outside air to the heater. Avoid space heaters that may "spit" diesel or gasoline onto nearby plants. Heated air should be circulated using a perforated "sock" or tube that runs the length of the greenhouse, or fans placed on opposite sides of the greenhouse and blowing in opposite directions. Place thermometers in several locations to measure the temperature at plant level. At least one high-low thermometer is a good investment.

For detailed information about greenhouse structures, see *Greenhouse Engineering* (NRAES-33), available from Plant and Life Sciences Publishing: palspublishing.cals.cornell.edu.

Transplant Containers

A wide variety of transplant containers are available, each with advantages and disadvantages. The most common ones are:

1. Todd planter trays made of Styrofoam (Speedling type).
2. Polystyrene or PVC flats or trays.
3. Peat strips, pots or pellets (e.g., Jiffy).

Peat pot containers have the advantage that the root system need not be disturbed upon planting. Peat pots also are more forgiving of over watering than other containers. If peat pots are planted partially above ground, moisture is "wicked" away from the plant, often resulting in plant death — peat pellets do not have this disadvantage.

Polystyrene and Todd planter flats are both designed so that transplants must be "popped" out of the trays, thus disturbing the root system. This is particularly true if the roots are allowed to grow into the ground beneath the tray. Avoid this problem by raising the flats off the ground. Both the polystyrene and Todd planter flats must be watered with care. Todd planter flats have a pyramidal design that forces roots downward to an open bottom where the roots are air pruned. Some polystyrene containers have open bottoms — tube types have open bottoms, groove types have small drainage holes.

In general, peat type containers are the most expensive, followed by the Todd planter type, then the polystyrene type.

The number of plants in a tray depends on the cell size for each plant. Vegetables are commonly grown in trays with 30 to 300 cells. In general, larger cells lead to greater early yield in fruiting crops. Larger cells are also easier to manage because the greater soil volume holds more water and nutrients. Due to the expense of building and maintaining greenhouse space, many growers have moved to smaller cell volumes so more transplants can be grown in the limited space available. Some growers use two different cell sizes: a larger size for crops they expect to harvest earlier, and a smaller size for crops they expect to harvest later.

Seeding and Growing

Most vegetable transplants are sown one seed per cell. As a general rule, plant vegetable seeds at a depth two times their diameter. Vegetable seeds temperature requirements vary; most vegetable seeds germinate in the 70°F to 90°F range. The time from seeding to transplanting varies from three to four weeks (e.g., cantaloupe) to 10 to 12 weeks (e.g., celery).

Vegetable seed may be ordered with special features, including seed priming and pelletizing. Primed seeds have been partially hydrated, then dried down, resulting in earlier germination and better uniformity. Priming may be useful for hard-to-germinate seed such as triploid watermelon. Seed may be pelletized to make it easier to handle. In this process, varieties with small seeds, or irregular seeds (such as lettuce) are coated to make the seed larger and uniform in size and shape. This process makes mechanized planting easier.

The growing mix should be well-drained and free of disease-causing organisms (pathogens). Most commercial mixes fit this description and perform well. These mixes are often referred to as "soilless mixes" since they are composed primarily of peat or coconut coir, perlite or vermiculite, and sometimes bark or ash. These mixes usually come in bales or bags and have been pasteurized (sufficiently heated to kill soil microorganisms capable of causing disease problems). It is advisable to test the mix before using it to make sure the pH is within an acceptable range (between 5.5 and 6.5) and to determine the initial nutrient content of the mix.

Most mixes include a small amount of fertilizer, but transplants usually benefit from additional regular nitrogen (N), phosphorus (P), and potassium (K) fertilization once true leaves appear. Depending on the initial nutrient level in the mix, including calcium (Ca) and magnesium (Mg) in the fertilizer solution may also be advised. Soluble synthetic fertilizers (21-5-20, 20-10-20) and liquid organic fertilizers (fish emulsion) are commonly used. The best rate, frequency, and method of fertilization will depend on your potting mix and watering practices. Common alternatives include a 50 to 200 ppm N solution applied at every watering, or a 300 to 500 ppm N solution applied weekly.

To make a 100 ppm N solution, use 0.42 pounds (6.6 ounces) of a 20 percent nitrogen fertilizer for every 100 gallons of water. Over-application of ammoniacal N can be detrimental to transplants. This problem can be minimized by not over-applying N, and by using fertilizer in which most N is in the nitrate form. Check the bag label.

Transplants that are too tall and tend to fall over are often referred to as "spindly," "shanky," or "leggy." Such transplants may have low survival rates in the field. Spindly transplants are produced under low light conditions, high fertilizer rates, and/or over watering. Cloudy weather or greenhouse structures that don't let in adequate light could be the culprits. Artificial lights could be helpful during inclement weather, but may be cost prohibitive.

Under such conditions, use a fertilizer containing a lower percentage of P. For instance, try 21-5-20 rather than 20-20-20. It is important to provide adequate P, but not too much. Under fertilization with P will produce short plants, but yields also will suffer. Hot days and cold nights favor leggy transplants. If night temperatures are equal to or higher than day temperatures, stem elongation will be reduced. It may be sufficient to lower the temperatures for a two-hour period starting at dawn.

To prepare transplants for the harsher environment of the field, it is necessary to harden them off. Transplants may be hardened off by withholding water and lowering temperatures moderately during the last week or so of growth. Some growers place transplants in wagons and wheel the transplants outside on appropriate days to get the plants used to field conditions. The transplants are wheeled back inside at night and during especially harsh weather.

After transplanting, plants should be irrigated as soon as possible. Some transplanters are equipped to irrigate plants at the time of transplanting. Otherwise, arrange to irrigate soon. Applying a small amount of starter fertilizer in the transplant water is often beneficial. If transplants are held in the greenhouse to replace those that don't survive, remember to avoid using transplants that have begun to vine or flower.

Diseases

Diseases that are likely to affect vegetable transplant production in the Midwest fall into two types: damping-off diseases (caused by soilborne fungi) and transplant diseases (usually associated with fungi, bacteria, or viruses that survive with seed or plant residue). These diseases can cause extensive transplant loss.

Damping off may occur before or after seedlings emerge from the soil. Preemergence damping off occurs when fungi infect seeds as they germinate. As infections progress, seeds rot and eventually disintegrate. Poor stands become apparent after several days or weeks.

Postemergence damping off is usually observed in seed flats or among transplants. Fungi infect stems at or near the soil surface. The affected area of the stem takes on a water-soaked appearance and sometimes becomes constricted. Eventually, the stems are unable to maintain the structural support of seedlings, which usually collapse and die within 24 to 48 hours.

Several soilborne fungi cause damping off on vegetables. *Fusarium, Phytophthora, Pythium,* and *Rhizoctonia* species are well known causal agents of pre- and postemergence damping off. Control measures to prevent damping off diseases Include:

- Using uncontaminated soil mix. Use a commercially prepared soilless growing mix sold in 3 to 4 cubic foot bales or bags. A common mistake is to open a bag of "clean" soil mix and place it on a dirty floor or some other unclean surface prior to planting. Remember that your soil is only as clean as the dirtiest surface it has contacted.
- Planting seeds shallow and in warm soil.
- Using soil mixes that drain well.

Seedborne and residueborne diseases affect most vegetable crops. The pathogens (disease-causing microorganisms) survive in or on seeds or plant residues, not in soil mixes. Outbreaks of these diseases often show up as clusters of diseased plants, and symptoms often include brown lesions with yellow halos on leaves. By contrast, environmentally induced problems often occur uniformly throughout the seedlings or only in one location (for example, close to an outside wall).

Several different fungal, bacterial, or viral pathogens may be introduced into a transplant facility via contaminated seed or transplants (Table 3). Once introduced, these pathogens may continue to cause problems year after year if proper precautions are not taken.

Table 3: Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants

Vegetable Crop	Disease
cabbage	black rot
	Alternaria leaf spot
cantaloupe	anthracnose
	gummy stem blight
cucumber	angular leaf spot
pepper	bacterial spot
squash	squash mosaic (squash mosaic virus)
tomato	bacterial canker
	bacterial speck
	bacterial spot
watermelon	anthracnose
	gummy stem blight
	bacterial fruit blotch

Several measures should be taken to minimize or prevent introducing seedborne or residueborne pathogens into a transplant facility:

- Avoid saving seed unless you are specifically trained and equipped for seed production.
- Inspect seedlings frequently while they are growing.
- Separate seedlots from one another. Save all information regarding seed purchases.
- Irrigate in the morning to ensure soil and leaf surfaces dry.
- Check fungicide and bactericide labels for specific mentions of greenhouse use when treating transplants (see Table 14 for liquid pesticide conversion table).
- Practice good sanitation. Plant pathogens often survive in soil and plant residues. Therefore, sanitation is as important for a greenhouse as it is for a kitchen. Greenhouse floors should be as free of soil and residue as possible; plastic or cloth floor coverings provide a barrier between dirt floors and transplants. Transplant trays and flats should be new or cleaned and disinfected before each transplant generation.

More detailed information about disease prevention and control in the greenhouse is available in *Preventing Seedling Diseases in the Greenhouse* (Purdue Extension publication BP-61-W), and *Commercial Greenhouse and Nursery Production: Sanitation for Disease and Pest Management*, available from the Purdue Extension Education Store (HO-250-W), www.the-education-store.com.

A few chemicals are labeled for disease control in greenhouse vegetable crops. Restricted use pesticides can only be used by certified pesticide applicators who have the greenhouse certification on their applicator licenses. Restricted use pesticides are identified prominently on the label.

If a pesticide is not restricted use and is labeled for the crop in question, check the label. If it does not mention greenhouse use, then it may be used in greenhouses. Otherwise, the label may explicitly prohibit greenhouse use. Thus, a specific label for greenhouse use for some products is not required; but you must carefully read each label to be certain the greenhouse use is not prohibited. Apply according to labeled rates and timing.

Products that may be used in the greenhouse are listed in tables 16 and 17 on pages 40 and 41.

Seed Treatments

Seed treatments are useful for preventing damping-off and some other root diseases in vegetable crops. Seed treatments can also eliminate certain pathogens carried in or on the seed.

There are two general types of seed treatment: eradicative and protective.

Eradicative seed treatments kill disease-causing agents on or within seed and are useful in controlling certain seedborne diseases.

Protective seed treatments are applied to the seed surface and protect the seed against decay and damping-off caused by soilborne organisms.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05, ohioline.osu.edu.

Hot Water Treatment

When properly used, hot water treatments kill most disease-causing organisms on or within seed. This treatment is suggested for eggplant, pepper, tomato, cucumber, carrot, spinach, lettuce, celery, cabbage, turnip, radish, and other crucifer seed. Improper

treatment can injure seed. Hot-water treatment can severely damage cucurbit seed.

Warm seed in a loosely woven cotton bag (not over half full) for 10 minutes in 100°F water. Place the warmed seed in a water bath that will constantly hold the water at the recommended temperature (see Table 4 below). The length of treatment and temperature of the water must be exact. After treatment, dip bags in cold water to stop heating action, and then spread seed out to dry. Always apply a protective seed treatment fungicide to hot-water-treated seed.

This treatment can injure old seed. Always test a small sample of any seed lot more than a year old by treating it, and testing for germination to determine the amount of injury, if any, that might occur.

Table 4: Water Bath Temperatures and Treatment Lengths

The water bath temperatures and treatment lengths should be followed exactly.

Seed	Temperature (°F)	Minutes
Brussels sprouts, cabbage, eggplant, spinach, tomato	122	25
Broccoli, cauliflower, cucumber, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	20
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

Chlorine Treatment

Chlorine treatment effectively removes bacterial and fungal pathogens on the seed surface. Chlorine treatment is recommended for pepper, tomato, cucurbits, and other vegetables if the seeds have not been treated by another method.

Agitate seeds in a solution of 1 quart of household bleach, 4 quarts of water, and 1 teaspoon of surfactant for 1 minute. Use 1 gallon of this disinfectant solution per pound of seed and prepare a fresh solution for each batch. After placing seed in this solution, remove, and rinse thoroughly in running tap water for five minutes. After that, spread out seed to dry. Dust the seed with Thiram 75WP® at 1 teaspoon per pound of seed.

Treat the seed near planting time, as viability may be reduced over time. Before you treat all seed, we recommend that you test a small sample of each seed lot first. Treat 50-100 seeds and see how they germinate. If they germinate well, treat the rest of the seed lot.

If you treat coated seed or seed treated with fungicide with hot water or bleach, always dispose of wastewater in an environmentally sound manner.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05, ohioline.osu.edu.

Fungicide Seed Treatment

Thiram is the most common seed-protectant fungicide. Other fungicides are recommended for specific crops. These fungicides are often combined with insecticides, and these combinations may be superior to fungicide treatment alone. Purchase treated seed, or dust seed lightly with fungicide according to label directions.

Do not use treated seed for food or feed.

Using Plastic Mulch

Black plastic mulch laid before planting helps control weeds, reduce root pruning, and give profitable increases in early yields of warm-season crops. Wavelength-selective and clear mulches typically lead to greater early yields than black plastic, but weed growth under these mulches may be a problem. This is particularly true for clear mulch. Because leaching is retarded, less fertilizer is lost, and nitrogen sidedressing is often unnecessary with the plastic mulch. If nitrogen needs to be added, it can be applied later through the irrigation system.

Try to lay plastic mulches as early in the season as possible. Mulches should be laid as soon as the ground can be worked after a heavy rain. Irrigate the field if soil moisture is not adequate prior to laying the mulch. Plastic mulches should be laid over moist soil. If the plastic is laid over dry soil, it will actually delay subsequent transplant growth. It is better to lay out plastic at midday so it can be stretched tight. However, do not overstretch the plastic because cool nights may actually cause it to tear.

The seedbed should be as fine as possible in order to get a good covering. The plastic is laid by burying about 6 inches of each edge. Black plastic mulch is most effective in warming the soil when it is in direct contact with the soil.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches, which degrade into small pieces of plastic that remain in the environment, are available. Biodegradable plastic mulches that break down completely are available.

Yields of pepper, eggplant, and summer squash are higher most years, and harvest can be up to seven days earlier than unmulched plantings. Clear plastic mulch is common in early sweet corn production. Growers can plant sweet corn in hills, single rows, or double rows, and apply herbicides before laying the plastic. Clear plastic mulch warms the soil and contributes to early harvest and quality produce.

Herbicides that were applied before the mulch was laid may break down before the crop matures. Unless otherwise advised, never apply herbicides over the top of plastic mulch. An alternative to the clear mulch/herbicide system is the IRT or *wavelength selective mulch* system. IRT mulches provide similar soil warming to clear film while controlling most weeds like black plastic.

Apply all fertilizer before laying the plastic, but reduce the total amount applied by 10-15 percent. Mulch layers are available in various widths. They also can be adapted for raised beds and for the laying of trickle irrigation tubes all in one operation.

Trickle irrigation combined with plastic mulch offers several advantages: it uses water economically, requires less energy for pumping, wets leaf surface less, allows for easy fertilizer application, provides a uniform moisture supply, and allows the application of certain insecticides and fungicides.

Irrigation and Water Management

Vegetables require an adequate supply of moisture throughout their entire growth. While the frequency and amount of water varies according to individual vegetable crop, its age, current soil moisture, soil type, and weather conditions, generally 1 to 1.5 acre inches of water are required each week.

Table 5: Effective Rooting Depth of Selected Vegetables

Shallow (6-12 inches)	Moderate (18-24 inches)	Deep (> 36 inches)
Beet	Cabbage, Brussels Sprouts	Asparagus
Broccoli	Cantaloupe	Lima Bean
Carrot	Cucumber	Pumpkin
Cauliflower	Eggplant	Sweet Potato
Celery	Pea	Watermelon
Greens & Herbs	Potato	Squash, Winter
Onion	Snap Bean	
Pepper	Squash, Summer	
Radish	Sweet Corn	
Spinach	Tomato	

Table 6: Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop[1]	Most Critical Period
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and maturation
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

[1]For transplants, transplanting and stand establishment represent a most critical period for adequate water.

The total available water holding capacity (AWHC) for a given location depends on soil texture, organic matter, and rooting depth. AWHC estimates are best obtained from the county soil survey or the local Soil and Water Conservation District office. Table 7 shows AWHC estimates for some typical soil textures in the upper Midwest. Irrigation should be initiated for most crops before 50 percent of the available water is removed by the plants in the active root zone. In most vegetable

crops, the majority of the roots are usually within the top 6 to 18 inches of soil. When using a trickle irrigation system on shallow-rooted, water sensitive crops (lettuce, peppers, etc.), the allowable depletion is generally 20 to 25 percent of AWHC and the system is run more frequently. With deeper rooted, more drought-tolerant crops (tomatoes, melons), a higher depletion allowance can be used without loss of yield or quality.

Table 7: Available Water Holding Capacities for Several Soil Types

Soil Texture	Available Water Holding Capacity	
	In Inches per Inch of Soil	In Inches per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

Soil Water Monitoring

Two common ways of estimating soil water deficit to assist irrigation scheduling are:

1. Measuring soil water tension with soil moisture sensors.
2. Measuring the feel and appearance of soil with a soil probe.

Soil water tension can be monitored at a given point in the active root zone by electrical resistance moisture blocks or tensiometers. Soil tension or suction is a measurement usually expressed in centibars that describes how tightly water is held to the soil particles.

Tensiometers directly read soil tension between 0 and 80 centibars and work best in sandy loam or lighter textured soils. Resistance blocks work in a wider range of soil textures, and some types, such as Watermark sensors, work as well in lighter textured soils, as do tensiometers. If the soil texture is known, use Table 8 (page 26) to estimate the inches of soil water deficit for a given tension reading; use Table 9 (page 27) to estimate the point of 20 to 25 percent depletion.

For example, let's say you have a sandy loam soil that has an AWHC of 1.5 inches per foot. A tomato crop would be irrigated when 50 percent (or about 0.7 inch) has been depleted in the upper foot of soil, or when a 6-inch tensiometer reads 45 centibars (Table 8). If we use the same soil for another example, a trickle-irrigated pepper crop would be irrigated when 20 to 25 percent (or 0.3 inch) has been depleted in the upper foot soil, or a 6-inch tensiometer reads 22 centibars (Table 9).

To obtain representative soil tension readings with any sensor, the sensors should be left installed throughout the irrigation season and preferably at two or more locations in the field. Two depths are generally desired at each location. These depths should be about one-third and two-thirds of the active root zone, or about 6 and 12 inches.

Your local Extension office will have more information about in-field soil moisture monitoring tools.

Table 8: Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions

Soil Texture	Soil Tension in Centibars						
	10	30	50	70	100	200	1,500[1]
	Soil Water Deficit — Inches per Foot of Soil						
Coarse sands	0	0.1	0.2	0.3	0.4	0.6	0.7
Fine sands	0	0.3	0.4	0.6	0.7	0.9	1.1
Loamy sands	0	0.4	0.5	0.8	0.9	1.1	1.4
Sandy loam	0	0.5	0.7	0.9	1.0	1.3	1.7
Loam	0	0.2	0.5	0.8	1.0	1.6	2.4

[1]1,500 cbs refers to the permanent wilting point and the soil deficit value is equal to the soil's total available water capacity.

Table 9: Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation

Soil Texture	0% Depletion of Available Water Holding Capacity (Field Capacity)[1]	20-25% Depletion of Available Water Holding Capacity[2]
	Soil Tension Values (in centibars)	
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

[1] At field capacity the soil contains 100 percent of AWHC; any excess water in the rootzone has drained away.

[2] Start trickle irrigation for shallow-rooted crops at this point.

Information adapted from *New Jersey Commercial Vegetable Production Guide*, New Jersey Ag Expt. Station, Rutgers; and *Water Management in Drip-irrigated Vegetable Production* by T.K. Hartz, UC-Davis, Calif., Vegetable Research and Information Center.

Frost Control

Irrigation can help protect vegetable crops, although it is not a common practice in the Midwest. With the proper equipment, growers must begin sprinkling as soon as the temperature reaches 34°F. Place a calibrated thermometer at the lowest elevation in the field at plant level, facing skyward. Continue sprinkling plants until the air temperature is greater than 30°F and the ice has melted from the plants.

To be effective, you need approximately 0.1 inch of water per hour, the sprinkling must be continuous, and the sprinklers should rotate at least once per minute. If conditions become windy and temperatures drop, it may be necessary to increase the amount of water to as much as 0.5 inch per hour. It is the process of the water freezing that gives off the heat to protect the crop. Therefore, liquid water must be present during the freezing period to protect the plants.

Bees and Pollination

Pollination is the transfer of pollen from the male portions of the flower (stamens) to the female portions of the flower (pistils). This process is vital to the production of many vegetable crops, including cucumber, cantaloupe, pumpkin, squash, and watermelon. Some crops (such as tomato) are self-fertile, but wind or bees must vibrate the flowers to release pollen for fertilization.

Honeybees are often thought of as the most prevalent pollinator for vegetable crops, but studies show that many species of native bees — including bumble bees and squash bees — play a vital role in pollinating many vegetable crops. Tomato, for example, benefit from the "buzz pollination" that bumble bees can provide. Honeybees are unable to buzz pollinate, and therefore do not play a role in tomato pollination. The squash bee, a North American native, is an important pollinator of pumpkins and other squash crops. Native bees are often active earlier in the day and at cooler temperatures than honeybees.

To ensure pollination, many vegetable growers rent honeybee hives rather than manage their own hives. Since honeybee colonies are occasionally in short supply, growers should communicate frequently with their bee providers.

In addition to renting honeybee hives, growers can improve the pollination services of native and non-native bees by increasing on-farm habitats. The Xerces Society for Invertebrate Conservation (www.xerces.org) and Pollinator Partnership (www.pollinator.org) offer guides, plant lists, and other resources about building on-farm bee habitats.

At least 90 crops grown in the United States depend to some extent upon bees as pollinators, either for seed or fruit production. The exact number of honeybee hives needed to pollinate a crop depends on a number of factors, including the strength and condition of colonies, magnitude of the natural pollinator community, amount of wild flower material competing with the crop, attractiveness of the crop to bees, projected yield, and weather.

The following are guidelines for the number of hives to use when supplemental pollination is desired:

cantaloupe	(2 to 3 colonies per acre)
cucumber	(2 to 3 colonies per acre)
pumpkin	(1 colony per acre)
squash	(1 colony per acre)
watermelon	(1 to 5 colonies per acre — the pollination requirements of seedless varieties are generally greater than seeded)

The following vegetables will set fruit without bees, but bee activity has been shown to increase yields:

eggplant	**okra**
lima bean	**pepper**

Honeybees do not assist in the pollination of the following crops, but will collect pollen and/or nectar from them:

pea	**sweet corn**
snap bean	**tomato**

Do not place hives in a field until the crop's flowers are available to visit. If the hives are placed before the flowers are available, the bees will forage to surrounding areas and may not forage sufficiently in the crop that needs pollination. Bees forage best within about 100 yards of the colony. Therefore, if the field is large, the bees should be distributed in clusters around the field.

Bees also require a source of clean water. If not available nearby, set out a shallow container with fresh water.

Bees and Pesticides

Certain pesticides and pesticide application practices pose serious hazards to honeybees and other bees. In general, nighttime applications pose the least hazard to bees, with early morning applications second best. Applying a single pesticide is usually less dangerous than applying combinations. Systemic insecticides are usually very safe to bees, as are granular formulations. Emulsifiable or water soluble formulations are safer than wettable powders of the same material.

The list on page 29 classifies insecticides by their degree of toxicity to honeybees. But remember: the label is the law, so read and follow it carefully. A list of chemicals and methods of application that are mutually agreeable to growers and beekeepers may be added to pollination contracts.

Growers should work closely with beekeepers to develop a pesticide application schedule and application program that protects their liability and the honeybees.

Ohio law requires applicators to notify beekeepers 24 hours before applying a pesticide labeled as toxic to honeybees if: (1) the crop to be treated is in bloom, and (2) the field is greater than a half acre and within half a mile of a registered apiary. Contact your state's department of agriculture to see if a similar law exists to protect pollinators.

Make sure to work with beekeepers to avoid applying pesticides that could harm the bees.

Table 10: Toxicity of Insecticides to Bees[1]

Some insecticides are more toxic to bees than others. It is important to realize the degree of toxicity and apply pesticides correctly. Application should be made when bees are not present—at night, very early in the morning or late in the evening.

Formulation affects the toxicity of an insecticide to bees. Wettable powders are more toxic than emulsifiable concentrates. For example, carbaryl in a 50WP formulation is much more toxic than carbaryl in a 4EC formulation.

The following insecticides and their toxicity to bees is presented as a guide, and is not intended to replace careful reading and following of the pesticide label. The label is the law.

Very High Toxicity[2]	High Toxicity[3]	Moderate Toxicity[4]	Low Toxicity[5]
*Actara® (thiamethoxam)	Agri-Mek® (abamectin)	*Acramite® (bifenazate)	*Beleaf® (flonicamid)
Agri-Mek® (abamectin), >21 fl oz/A	Asana® (esfenvalerate), 4.8 fl oz/A	Ammo® (cypermethrin), ≤1.28 fl oz/A	*Courier® (buprofezin)
Ambush® (permethrin)	Capture 2EC® (bifenthrin), 2.56 fl oz/A	*Assail® (acetamiprid)	Cryolite® (cryolite)
Ammo® (cypermethrin), >1.28 fl oz/A	Confirm® (tebufenozide) ≤21 fl oz/A	*Avaunt® (indoxacarb)	*Dimilin® (diflubenzuron)
Asana® (esfenvalerate), 7.3 fl oz/A	Dibrom EC® (naled)	Azatin® (neem)	DiPel® (*Bacillus thuringiensis*)
Baythroid® (cyfluthrin)	Di-Syston 8EC®, 16 fl oz/A	Capture 2EC® (bifenthrin), <2.56 fl oz/A	Diazinon G® (diazinon)
Brigade 2EC® (bifenthrin), >23.8 fl oz/A	Malathion EC® (malathion)	*Decis® (deltamethrin)	Di-Syston G® (disulfoton)
Danitol® (fenpropathrin)	*Proaxis® (gamma-cyhalothrin), 2.56 fl oz/A	Diatect® (diatomaceous earth)	*Esteem® (pyriproxyfen)
Diazinon® (diazinon)	Provado® (imidacloprid), 8 fl oz/A	Di-Syston EC® (disulfoton), 8 fl oz/A	Garlic Barrier®
Dibrom® WP or D (naled)	Sevin XLR+®, ≤48 fl oz/A	Fulfill® (pymetrozine)	Hot Pepper Wax® (capsaicin)
Dimethoate® (dimethoate)	Thimet EC® (phorate)	Lannate® (methomyl)	*Intrepid® (methoxyfenozide)
Guthion® (azinphosmethyl)	Vydate® (oxamyl), ≥64 fl oz/A	Malathion ULV® (malathion), <3 fl oz/A	Kryocide® (cryolite)
Imidan® (phosmet)	Warrior® (lambda-cyhalothrin), 2.56 fl oz/A	Metasystox-R® (oxydemeton methyl)	Malathion G® (malathion)
Lorsban® (chlorpyrifos)		Neemix® (neem)	Metaldehyde® Bait (metaldehyde)
Malathion WP® (malathion)		Proclaim® (emamectin benzoate)	Mocap G® (ethoprop)
Malathion ULV® (malathion), >8 fl oz/A		Rotenone® (rotenone)	M-Pede® (soap)
Mustang® (zeta-cypermethrin)		SpinTor® (spinosad)	Mycotrol® (*Beauveria*)
Orthene® (acephate)		Thimet G® (phorate)	Sevin G® (carbaryl)
Penncap-M® (methyl parathion)		Thiodan® (endosulfan), ≤85 fl oz/A	Sevin Bait G® (carbaryl)
Pounce® (permethrin)		Trigard® (cyromazine)	sulfur (sulfur)
*Proaxis® (gamma-cyhalothrin), 3.84 fl oz/A		Vydate® (oxamyl), ≤32 fl oz/A	*Surround® (kaolin)
Sevin 50WP® (carbaryl)			Vendex® (fenbutatin-oxide)
Sevin XLR-Plus®, >48 fl oz/A			
Warrior® (lambda-cyhalothrin), 3.84 fl oz/A			

[1]**Source:** *How to Reduce Bee Poisoning from Pesticides*. Pacific Northwest Extension Publication PNW 518.
[2]Do not apply these to blooming crops or weeds at any time of day or night.
[3]Apply only during late evening (6 pm to midnight).
[4]Apply only during late evening, night or early morning (6 pm to 7 am).
[5]Can be applied at any time with reasonable safety to bees.
*Products marked are relatively new and do not appear in the source cited, but information on their toxicity was taken from various Extension sources.

Table 11: Approximate Time from Pollination to Market Maturity Under Warm Growing Conditions

Vegetable	Days to Market Maturity
Bean	7-18
Cantaloupe	40-50
Corn, market	18-23[1]
Corn, processing	21-27[1]
Cucumber, pickling (3/4-1 1/8-inch diameter)	4-5
Cucumber, slicing	15-18
Eggplant (2/3 maximum size)	25-40
Okra	4-6
Pepper, green stage (about maximum size)	45-55
Pepper, red stage	60-70
Pumpkin, jack-o-lantern	60-90
Pumpkin, baking	65-75
Squash, summer, zucchini	3-4[2]
Squash, winter, butternut	60-70
Squash, winter, hubbard	80-90
Squash, winter, acorn	55-60
Tomato, mature green stage	34-45
Tomato, red ripe stage	45-60
Watermelon	40-50

[1]From 50% silking.
[2]For a weight of 0.25-0.5 lbs.

Precautions with Pesticides

Pesticides are designed to poison or otherwise manage pests. Many pesticide products may poison people, pets, livestock, wildlife, ornamental plants, and other non-target organisms. Pesticide applicators and their families are at increased risk of pesticide exposure. It is important to keep all pesticide exposures to an absolute minimum.

You must protect your family members, field workers, and other people from pesticide injuries. Most pesticide accidents result from careless practices or lack of knowledge about safe handling. The time you spend to learn about the safe use of pesticides is an investment in the health and safety of you, your family, and others.

The U.S. Environmental Protection Agency (EPA) places certain restrictions on the use of pesticide chemicals. These restrictions apply to chemicals applied to control insects, mites, plant diseases, weeds, nematodes, and other pests. Such restrictions may prohibit the use of a chemical or allow residue tolerances on harvested vegetables. Growers must know what chemical to use on each vegetable; how to apply the products; the post-treatment re-entry interval, if any; when to use the chemicals with respect to farm worker and/or picker safety; and the environment and the harvest of each vegetable crop.

Growers must follow all label instructions regarding harvest restrictions to assure consumers that the food is free of dangerous residues and to comply with the law to prevent seizure of their crops. Here are some rules for the safe use of pesticides:

- Only mix the amount of a pesticide you can use in one day
- If you do have leftover spray mix, the best way to dispose of it is by applying it to a labeled crop in a legal manner
- Never dispose of surplus pesticides in a way that will result in the contamination of ground or surface waters
- Rinse all empty containers three times before disposal.
- Pour the rinse water into the spray tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any other purpose.
- Then dispose of the container according to label directions.

Pesticide Signal Words

Each pesticide container is required by law to have signal words to quickly communicate information about the product's possible toxicity. The three signal words, as provided by the National Pesticide Information Center, are:

- CAUTION. This signal word means the pesticide is slightly toxic if eaten, absorbed through the skin, or inhaled, or it causes slight eye or skin irritation.
- WARNING. This signal word means the pesticide is moderately toxic if eaten, absorbed through the skin, or inhaled, or it causes moderate eye or skin irritation.
- DANGER. This signal word means the pesticide is highly toxic by at least one route of exposure. It may be corrosive, which would cause irreversible damage to the skin or eyes. It may be highly toxic if eaten, absorbed through the skin, or inhaled. If this is the case, then POISON must also be included in red letters on the front panel of the product label.

Rules for Pesticides with 'Danger' Signal Word

Formulations of Monitor®, Lannate®, Thimet®, DiSyston®, Guthion®, and Gramoxone® are highly poisonous. They should not be applied unless applicators strictly follow all precautions listed on pesticide labels.

Some label precautions include:

- Wearing the proper respiratory equipment when handling or applying.
- Wearing protective clothing that covers as much of the body as possible.
- Always using rubber gloves, not leather or cloth gloves, and never use bare hands to handle pesticides.
- Not breathing in these pesticides when opening containers or mixing into spray tanks.
- Always washing hands, arms, and face immediately after handling, and before eating or smoking.
- Never smoking while handling or applying.
- Reducing all possible hazards of coming into direct contact with spray drift, and avoiding spraying if conditions are too windy.
- Showering or bathing thoroughly after each day's work, and changing clothes.
- Washing spray clothes separately from the family wash, then running another complete hot water and detergent wash cycle before washing other clothes.
- Wearing clean overalls, underwear, socks, and cap each day you spray.
- Always keeping pesticides in their original labeled containers, and storing in a safe place.
- Storing and disposing containers according to information on pesticide labels.

Restricted Pesticides

Most states have laws that restrict the use of certain pesticides and that describe where such pesticides can be obtained and used. Only individuals who are licensed by the state can apply restricted use pesticides.

Some restricted pesticides require applicators to notify occupants of land within 1,000 feet of the area to be treated at least 24 hours before application. Occupants also must be notified of any precautions they must take to ensure the safety of livestock and humans.

The U.S. EPA, state regulatory agencies, or pesticide companies can label specific pesticide formulations as "Restricted Use Only." To learn more about your state's laws about restricted use pesticides, contact your state department of agriculture or local extension office.

Handling Pesticides

Ground Equipment

Boom-type Sprayers

High-pressure, high-volume sprayers have been used for row-crop pest control for many years. However, there is a growing trend to use sprayers that use lower volumes and pressures, and satisfactory pest control is possible at lower rates (if the sprayer is properly calibrated).

Boom Sprayer Calibration

For effective applications, make sure to calibrate boom sprayers carefully. To calibrate a boom sprayer:

1. Clean the sprayer and replace all worn parts
2. Fill the tank with water.
3. Adjust sprayer pressure and tractor speed for nozzle size and output by following manufacturer's directions.
4. Spray 1/8 of an acre (5,445 square feet) — the actual distance you travel will vary with boom width. For example, a 22-foot boom must travel 248 feet to cover 5,445 square feet.

$$\frac{\text{1/8 A (5,445 square feet)}}{\text{Boom width (22 feet)}} = \frac{\text{Distance}}{\text{(248 feet)}}$$

5. After spraying, measure the amount of water you need to refill the tank. This is the amount you applied to the test area of 1/8 acre; thus, you need 8 times that amount to spray an acre.
6. Adjust spray output by varying the tractor speed or changing the nozzle sizes or pressure. Recalibrate after making any adjustments.
7. Calculate the acres covered by the tank of spray solution and add the required amount of pesticide for the total area to be sprayed.

It is of utmost importance that the spray unit functions properly. To obtain complete plant coverage and penetration, check the cleanliness of nozzles, nozzle wear, boom height, pressure gauge accuracy, agitation in tank, forward ground speed, mixing of materials, and nozzle spacing.

Also, due to lower pressures and volumes, paying attention to the wind becomes more important. Avoid using a boom-type sprayer in high winds. For more information, see *Boom Sprayer Calibration* (Ohio State University Extension FactSheet AEX-520-92), available from Ohioline, ohioline.osu.edu.

Airblast-type Sprayers

Vegetable growers use airblast sprayers to control insects and diseases. However, pest control has been erratic. Airblast sprayer operation is more critical than a boom-type sprayer, so the operator must fully understand the machine and the job.

Do not operate an airblast sprayer under high-wind conditions. Preferably, that means wind speeds should be less than 5 mph unless it is necessary to apply the pesticide for timely control — even then, applicators must consider drift.

Do not overextend the coverage of the machine. Considerable visible mist from the machine moves into the atmosphere and does not deposit on the plant. If in doubt, use black plastic indicator sheets in the rows to determine deposit and coverage before a pest problem appears as evidence.

Use the correct gallonage and pressures to obtain proper droplet size to ensure uniform coverage across the effective swath width.

Adjust the vanes and nozzles on the sprayer unit to give best coverage. Vane adjustment must occur in the field, depending on terrain, wind, and crop.

Cross drives in the field allow the material to be blown down the rows instead of across them and help to give better coverage in some crops, such as tomatoes.

Sprayer Delivery Rates

It is essential to apply pesticides at the specified rates for best control and protection and to not exceed residue tolerance. Check sprayers carefully several times a season for accurate delivery rates. Use new nozzle disks when needed. Use a speedometer operated from a nondriven wheel to determine the speed and delivery rate of the sprayer.

Water Quality and Pesticide Applications

Water that is added to the pesticide spray tank may vary in pH, hardness and other qualities. These variations in water types may influence the effectiveness of the pesticide application. To learn about this subject, see *The Impact of Water Quality on Pesticide Performance* (Purdue Extension publication PPP-86) available from the Education Store, www.the-education-store.com.

Evaluating Compatibility of Pesticides Before Tank-mixing

1. Read the label and follow directions. If the label states, "Do not mix with other products," that direction must be followed.
2. Add products to the mix in this order:
   a. Wettable powders.
   b. Flowables.
   c. Water-solubles.
   d. Adjuvants.
   e. Emulsifiable concentrates.
3. If using different products, and one label states, "Add last to spray tank," that direction must be followed.
4. If the label states, "Do not use adjuvants," that direction must be followed.
5. Add 1 pint of the carrier to a 1-quart jar. Use the same water or liquid fertilizer that will be used in the field.
6. Add 1 1/2 teaspoon of the wettable product(s) for each pound per acre to be used.
7. Next, add 1 teaspoon for each quart per acre of the liquid to be used.
8. These ratios will approximate 25 gallons per acre.
9. Shake the jar after adding each ingredient, and let it stand for a few minutes to see if there is a reaction. Keep adding each ingredient until all are added.
10. If there is a precipitate, or the material greases out, don't use it in the field.
11. The allowable separation in the jar depends on the amount of agitation in your equipment.
12. Good agitation is very important.
13. Storage conditions also are important.
    a. Temperature: read the label for precautions.
    b. Avoid contamination.
    c. Do not leave material in the spray tank overnight or for more than several hours.

14. Normally, if there are problems, a compatibility agent will help.
15. This test only indicates physical compatibility; it does not indicate chemical reactions between products.

Pesticide Formulations

The common types of pesticide formulations are:

- **Emulsifiable concentrates (EC):** the pesticide is dissolved and the emulsifying agent is added to an organic solvent.
- **Wettable powders (WP or W):** the pesticide is absorbed or adsorbed on powders that can be mixed with water because of an added wetting agent.
- **Dusts (D):** the pesticide is diluted with finely divided and ground materials.
- **Solutions:** the pesticide has a molecular mixture with the solvent.
- **Microencapsulated:** the pesticide is placed in pinhead-sized capsules that disintegrate slowly over a period of time.

Pesticides must be properly formulated and diluted to prevent injury to plants. Often, physical properties of certain pesticides make dilution difficult, leaving lasting residues that are hazardous to edible crops. New formulations enter the market each year.

Storing Pesticides for Next Season

Growers who store pesticides always should consider safety and product quality, whether they will store products for a few weeks or a year or more. It is best not to have leftover pesticides. However, there usually are surplus pesticides at the end of the season because preseason purchases often are very economical.

Before storing pesticides always:

1. Read product labels. Certain formulations or products have special storage requirements, which are printed on the label.
2. Make certain the label is in good condition (legible) to know what is in the container and for directions for safe, effective, and legal use.
3. Write the purchase or delivery date on the label. Store the oldest materials near the front of the storage area and use older or opened products first. Products that are several years old may not be effective.
4. Keep an up-to-date inventory of pesticides to assist in purchase decisions and in emergencies.
    a. Maintain storage temperatures between 32°F and 100°F. Ventilation is important for storage of most pesticides. Keep pesticides dry and out of direct sunlight.
5. Store herbicides away from other pesticides to prevent use mix-up, contamination, and possible plant damage. Never store pesticides with food or seed or near food or drinking water.
6. Permanently identify and lock pesticide storage areas.
7. Keep a supply of cat litter or other absorbent material in the storage to scatter over spills of liquid chemicals.
8. Hang a Class B inflammable liquids fire extinguisher nearby.

Here are some common pesticides with observations on their shelf-life under normal conditions:

Insecticides

- acetamiprid (Assail®): Several years.
- carbaryl (Sevin®) WP: Several years.
- carbaryl (Sevin®) F: Watch for settling.
- Diazinon EC®: 5-7 years if tightly sealed.
- Disulfoton (Di-Syston®): 2 years.
- Malathion WP®: Many years, but decomposes under high temperatures.
- Metasystox-R®: 2 years.
- Methoxychlor®: Many years.
- phosmet (Imidan®) WP: 2-3 years.

Herbicides

- glyphosate (Roundup®): 2 years, but do not allow to freeze.
- Casoron® (G): 2 years if cool and dry.
- Dacthal® (WP): 2 years.
- Kerb® (WP): 2 years.
- simazine (Princep®) (G, WP): Many years.
- Surflan® (G): 3 years, must be mixed well.
- Treflan® (G): 3 years if dry and under 80°F.

Empty Containers

Most states have regulations that regulate the disposal of pesticide containers. The regulations often require that hazardous materials containers be disposed of in designated hazardous waste sites unless commerical applicators meet triple-rinsing and other requirements.

However, farmers and private applicators may be exempt from the regulations as long as they follow all label instructions when disposing of waste pesticides and containers.

Reduced-risk (RR)/Biopesticides (BP)

Every pesticide has a different impact on human health and the environment. Until recently, it has been impossible for growers to know the impact of the pesticides they apply. Now, however, the U.S. Environmental Protection Agency (EPA) lists biopesticides and pesticides that have reduced risks in specific areas.

Pesticides classified as reduced-risk by the EPA are conventional products that have:

- Low impact on human health.
- Low toxicity to nontarget organisms (birds, fish, and plants).
- Low potential for groundwater contamination.
- Lower use rates.
- Low pest resistance potential.
- Compatibility with Integrated Pest Management.

The EPA bases reduced-risk decisions on specific uses of pesticide combinations. Thus, a pesticide may be considered reduced risk for one vegetable, but not another.

Biopesticides are derived from natural materials such as animals, plants, bacteria, and certain minerals. Biopesticides fall into three major classes: microbial pesticides, plant-incorporated protectants, and biochemical pesticides. The active ingredient in a microbial pesticide (or mycoinsecticide) is a microorganism (bacterium, fungus, virus, or protozoa). These are highly selective in activity against specific target insect pests. Plant-incorporated protectants are substances that plants produce based on genetic material that is incorporated into plants. Biochemical pesticides are naturally occurring substances that control insect pests through nontoxic mechanisms such as sex pheromones or scented plant extracts.

The EPA defines biopesticides as products that include: "naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) or PIPs."

In this guide, products that are defined as reduced risk for a given vegetable or vegetable group are denoted by the symbol (RR). Biopesticides are denoted by the symbol (BP).

As with any product, investigate these or any new products before you need them. If a product is not commonly used in your area, it may not be locally or quickly available.

More information about the EPA's Reduced Risk Pesticide Program is available at www.epa.gov/opprd001/workplan/reducedrisk.html. More information about the EPA's biopesticide program is available at www.epa.gov/oppbppd1/biopesticides/whatarebiopesticides.htm.

Pesticide Application Record[1] and Written Notification for EPA Worker Protection Standards[2]

Business Name														
Location		Pesticide				Application								
Field	Crop	Product Brand Name & Chemical Formulation[3]	Active Ingredient	Name of Manufacturer	EPA Registration Number	Pest Controlled	Area Treated (Sq. ft. or Acres)	Pesticide Rate	Total Amount of Pesticides Used	Name & Certification No. of Applicator or Certified Supervisor	Date (Mo./ Day/ Year)	Time	Restricted Entry Interval (hrs.)	OK to Enter (Date & Time)

[1]Information required by Federal and State Recordkeeping Requirements for Certified Applicators of Federally Restricted Use Pesticides (RUP). Records for restricted use pesticides must be maintained for two years from date of pesticide application.

[2]For EPA Worker Protection Standard, information in shaded columns must be recorded for all pesticides and be maintained at the centrally located posting area for 30 days after the restricted entry interval expires.

[3]Formulation required if included in product name: DF=dry flowable, EC & E=emulsifiable concentrate, G=granules, F=flowable, L=liquid, S=soluble, ULV=ultra low volume, etc.

This form was prepared by a joint effort of the Northwest Horticulture Program, Department of Horticulture and Landscape Architecture, and Purdue Pesticide Programs, Purdue University.

Organic Vegetable Production

Organic vegetable farming is a production system that relies on biological processes and natural materials to manage soil fertility and pest populations, and to promote healthy crop growth. With the federal Organic Foods Production Act, use of the term "organic" to describe an agricultural product in the marketplace is regulated. Vegetables sold as "organic" must be grown and handled according to the National Organic Rule and any applicable state regulations. The National Organic Rule prohibits the use of most synthetic chemicals (fertilizers, pesticides, etc.), and requires farmers to write and follow organic production plans, as well as keep farm and field records. Fields used to grow organic crops may not have had any prohibited material applied to them in the previous three years. In addition, USDA-accredited organic certification agents must inspect and certify all operations with more than $5,000 in gross annual income from sales of products labeled "organic."

Growers interested in transitioning to organic production should educate themselves about practices used in their area and plan carefully. Experience suggests that it can take a number of years for pest populations and soil nutrient cycles to adjust enough for successful organic production. Portions of this guide related to soil sampling, nutrient availability, and crop nutrient requirements include information relevant to organic production, as do the overviews of Insect Management Strategies, Disease Management Strategies, and Weed Management Strategies.

In this guide, products that may be allowed in organic production are denoted by the symbol: . Growers should always check with their organic certification agents before using any product to make sure it meets their certifier's criteria.

Other organic production resources include:

eXtension, the national extension website, offers resources on organic agriculture at www.extension.org.

Organic Vegetable Production (Purdue Extension publication ID-316) is an introductory guide covering the basics of soil fertility and pest management (available online at www.extension.purdue.edu/extmedia/ID/ID_316.pdf).

Organic Vegetable Gardening Techniques (University of Missouri Extension Guide G6220) provides an introduction to organic production techniques (available online at muextension.missouri.edu/xplor/agguides/hort/g06220.htm).

Resource Guide for Organic Insect and Disease Management (Cornell University) provides specific recommendations for pests and diseases of major vegetable crops (available online at www.nysaes.cornell.edu/pp/resourceguide).

Appropriate Technology for Rural Areas (ATTRA) offers a number of publications on their website: www.attra.org.

The National Organic Program (NOP) offers a program handbook that provides a list of materials allowed for use in organic production, plus a complete list of accredited certification agents on their website: www.ams.usda.gov/nop.

The Organic Materials Review Institute (OMRI) publishes a list of products they have found to meet certified organic production criteria. For details, visit www.omri.org.

The Sustainable Agriculture Research and Education (SARE) program offers a number of research-based publications about pest management, including organic options. A complete catalog is available at www.sare.org/Learning-Center.

If you desire organic certification, you should contact a certification agent during the period of transition to organic production. The organizations on page 37 have been accredited by the USDA as of September 2014. Contact them directly for information about fees and the certification procedure. Although they are listed by state, many organizations work across state lines; you do not have to choose an organization in your state. Additional accredited organizations are listed at www.ams.usda.gov/nop.

Consult your local Extension office for other resources available in your area.

Indiana

Ecocert ICO
70 East Main St., Suite B
Greenwood, IN 46143
(888) 337-8246
(317) 865-9700
Fax: (317) 865-9707
www.ecocertico.com
info.ecocertico@ecocert.com

Iowa

Iowa Department of Agriculture and Land Stewardship

Organic Certification Program
Maury Wills
502 East 9th Street
Des Moines, IA 50319
(515) 281-5783
www.iowaagriculture.gov/AgDiversification/organicCertification.asp
AgDiversification@iowaagriculture.gov

Kansas

There is no certification agent in Kansas, however agencies located in other states serve Kansas growers.

OCIA International, INC
1340 North Cotner Blvd.
Lincoln, NE 68505
Phone: (402) 477-2323
Fax: (402) 477-4325
info@ocia.org
www.ocia.org

Minnesota

Midwest Organic Services Association, Inc. (MOSA)
122 W. Jefferson St.
P.O. Box 821
Viroqua, WI 54665
(608) 637-2526
www.mosaorganic.org
mosa@mosaorganic.org

Minnesota Crop Improvement Association
1900 Hendon Ave.
St. Paul, MN 55108
(612) 625-7766
(800) 510-6242
www.mncia.org
mncia@mncia.org

Missouri

There is no certification agent in Missouri, however agencies located in other states serve Missouri growers.

Ohio

Ohio Ecological Food and Farm Association
Certification Program
41 Croswell Road
Columbus, OH 43214
(614) 262-2022
www.oeffa.org
organic@oeffa.org

Table 12: Yields of Vegetable Crops

Crop	Expected Yields in Tons per Acre		
	Average	Good	Excellent
Asparagus	1	1.5	2
Bean, Snap	2	3	4
Cabbage	13	15	20
Cantaloupe	10	15	19
Corn, Sweet	4.5	8	10
Cucumber (slicing)	9	12	15
Cucumber (pickling, hand harvest)	6	10	12
Onion	13	18	23
Pepper, Green	14	17	20
Potato (fall)	10	15	20
Pumpkin	10	15	25
Spinach	6	8	10
Summer Squash	10	13	16
Sweet Potato	7	12	15
Tomato (fresh market)	11	13	15
Tomato (processing)	25	29	33
Watermelon	15	20	25

This table only provides general yield estimates for new or prospective growers. The USDA-National Agricultural Statistics Service Vegetable Survey provides more accurate information, www.nass usda.gov/Surveys/Guide_to_NASS_Surveys/Vegetables/index.asp.

Table 13: Postharvest Handling and Storage Life of Fresh Vegetables

Give careful attention to the postharvest handling and storage of fresh market vegetables. Lack of adequate refrigeration and cooling will result in a shortened shelf-life and lower quality of the fresh vegetable. The following list of recommended storage condition information is modified from the USDA's Agricultural Handbook No. 66, and *Knott's Handbook for Vegetable Growers* (Donald N. Maynard and George J. Hochmuth, 5th ed. 2007).

Vegetable	Storage Conditions		
	Temperature (˚F)	Relative Humidity (%)	Relative Storage Life
Broccoli	32	95-100	10-14 days
Cabbage, late	32	98-100	5-6 months
Cantaloupe	36-41	95	10-15 days
Cauliflower	32	95-98	3-4 weeks
Corn	32	95-98	2-5 days, up to 21 days for supersweet cultivars
Cucumber	50-55	90-95	10-14 days
Watermelon	50-60	90	2-3 weeks
Pepper, green	45-55	90-95	2-3 weeks
Pepper, ripe	42-45	90-95	1 week
Potato, early	[a]	90-95	[a]
Potato, late	[b]	90-95	[b]
Pumpkin	50-55	50-70	2-3 months
Squash, winter	50-55	50-70	[c]
Sweet potato	55-60	85-90	5-6 months
Tomato, mature-green	55-62	90-95	1-2 weeks
Tomato, firm-ripe	45-50	90-95	4-7 days

[a]Most summer-harvested potatoes are not stored. However, they can be held 4-5 months at 40˚F if cured 4-5 days at 60-70˚F before storage. They can be stored 2-3 months at 50˚F without curing. Potatoes for chips should be held at 70˚F or conditioned for best chip quality.

[b]Fall-harvested potatoes should be cured at 50-60˚F and high relative humidity for 10-14 days. Storage temperatures for seed or table stock should be lowered gradually to 38-40˚F. Potatoes intended for processing should be stored at 50-55˚F. Those stored at lower temperatures or with a high reducing sugar content should be conditioned at 70˚F for 1-4 weeks or until trial cooking tests are satisfactory.

[c]Winter-squash varieties differ in storage life. Acorn squash can be stored for 35-55 days, butternut squash for 60-90 days, and Hubbard squash for 180 days.

Be sure the temperature is not too low. Cucumber, eggplant, lettuce, sweet pepper, potato, snap bean, squash, and tomato are among the most susceptible vegetables to chilling or freezing injury. Some of the typical cold injury symptoms that can make vegetables unmarketable include pitting, water-soaked spots, browning, surface decay, and, in pepper and tomato, failure to ripen.

Follow good agricultural practices and sanitation procedures throughout harvest, grading, and packaging operations. More information is available in *Food Safety Begins on the Farm: A Grower's Guide* from Cornell University. Visit the Cornell Good Agricultural Practices Program at www.gaps.cornell.edu.

Table 14: Conversions for Liquid Pesticides on Small Areas

Rate per Acre	Rate per 1,000 Square Feet	Rate per 100 Square Feet
1 pint	0.75 tablespoon	0.25 teaspoon
1 quart	1.5 tablespoons	0.5 teaspoon
2 quarts	3 tablespoons	1 teaspoon
1 gallon	6 tablespoons	2 teaspoons
25 gallons	4.5 pints	1 cup
50 gallons	4.5 quarts	1 pint
75 gallons	7 quarts	1.5 pints
100 gallons	9 quarts	1 quart

Check the pesticide label for the particular crop, pest, and site of your planned use.

Tomato seeds that have been pelleted for ease of handling (left) will have a lower number of seeds per ounce than unpelleted seeds (right). See Table 15 (page 39).

Table 15: Germination and Growing Guide for Vegetable Plants and Herbs

Crop	No. of Seeds per Oz	Opt. Germination Temp. (°F)	Usual Day Temp. (°F)	Min. Night Temp. (°F)	Time for Uniform Germination (days)
Asparagus	700	75			10-21
Broccoli	9,000	68-86	65-70	60	5-10
Brussels sprouts	9,000	68-86			5-10
Cabbage	9,000	85	65	60	5-10
Chinese cabbage	18,000	85			3-7
Cauliflower	9,000	80	65-70	60	5-10
Celery	72,000	70	65-70	60	10-21
Collards	9,000	68-86			3-10
Cucumber	1,100	68-86	70-75	65	3-7
Dandelion (for greens)	35,000	68-86			7-21
Eggplant	6,500	85	70-85	65	7-14
Endive	27,000	68-86	70-75	70	5-14
Kale	9,000	68-86			3-10
Leek	11,000	68			6-14
Lettuce	25,000	75	60-65	40	7
Okra	500	68-86			5-14
Pak-choi	18,000	68-86			3-7
Parsley	18,500	75			11-28
Pepper	4,500	85	70-75	60	6-14
Sweet potato plants (from tuberous roots bedded in sand)		77	75-85		14-21
Squash	400	80-90	70-75	65	4-7
Tomato	11,500	85	65-75	60	5-14
Herbs					
Anise	9,600	70			5
Basil, dark opal	20,000	70			10
Basil, leaves	9,600	70			10
Borage	2,100	70			8
Chives	22,000	60			10
Coriander	1,240	70			10
Dill	6,300	60			10
Fennel, sweet	4,000	65			10
Marjoram, sweet	100,000	70			8
Rosemary	30,000	60			15
Sage	3,250	70			15
Thyme	96,000	75			10

Pesticide Use in Greenhouses and High Tunnels

Vegetable production in greenhouses and high tunnels has increased dramatically in the Midwest in the past few years. Although greenhouse or high tunnel environments may change the composition of the pest complex growers may face, using pesticides will often be necessary to maintain the adequate levels of control needed to produce a profitable and marketable crop.

The pesticide regulatory agencies in the Midwest states vary in their interpretation of whether a high tunnel is a type of greenhouse. For example, Indiana considers a high tunnel to be a form of greenhouse. That means the pesticides one selects for high tunnel use must be appropriate for greenhouse use.

Other states consider high tunnels to be the same as fields when it comes to pesticide use. Still other states, like Missouri, take an intermediate approach: they call a high tunnel a greenhouse when the sides are *closed,* but call it a field when the sides are *open*. It is important that you determine how your state views high tunnels.

When it comes to greenhouse pesticide applications, there are three kinds of labels.

First, pesticide labels can clearly state that the products may be used in greenhouses. These products may be used according to label directions. Pesticide labels that have different instructions for greenhouse use and in-field use also fall into this category. These products also may be used according to label instructions.

Second, pesticide labels may clearly prohibit greenhouse use. Obviously, these products cannot be used in a greenhouse under any circumstances.

Finally, there are many pesticide labels that don't specify whether the product can be used in a greenhouse or not. When labels don't expressly prohibit greenhouse use, most state regulatory agencies interpret that to mean that the product can be used in a greenhouse as long as the treated crop is on the label and the product is used according to label directions.

Table 16 classifies common insecticides according to these labels. Table 17 classifies common fungicides.

Table 16: Insecticide Labeling for Greenhouse Use[1]

Labeled for Greenhouse Use	Label Prohibits Greenhouse Use	Label Silent on Greenhouse Use
Admire®	Actara®	Acramite®
Agree®	Belt®	Agri-Mek®
Avaunt®[2]	Coragen®	Ambush/Pounce®
Dibrom®[3]	Di-Syston®	Ammo®
DiPel®	Diazinon®	Asana®
Entrust®	Dimethoate®	Assail®
Exirel®	Endosulfan®	Baythroid®
Intrepid®	Movento®	Belay®
Lannate®	Oberon®[4]	Brigade®
Monitor®	Orthene®	Cryolite®
M-Pede®	Platinum®	Danitol®
Neemix®	Proclaim®	Fulfill®
Sevin®	Radiant®	Hero®
Vydate®	Synapse®	Knack®
	Trigard®	Kryocide®
	Voliam Flexi®	Larvin®
	Voliam Xpress®	Lorsban®
		Malathion®
		Mustang Max®
		Penncap-M®
		Rimon®[5]
		Warrior®

[1]For example, a tomato grower in the field can use any of the 18 products on pages 135-136 to treat hornworm in tomato. The same grower could use 15 products in the greenhouse (three products prohibit greenhouse use, the others specifically mention greenhouse use or do not mention greenhouse use).
[2]Not for brassicas.
[3]Additional restrictions for greenhouse use.
[4]Oberon 2SC® only.
[5]Only for greenhouse tomatoes.

Table 17: Fungicide Labeling for Greenhouse Use[1]

Labeled for Greenhouse Use	Label Prohibits Greenhouse Use	Label Silent on Greenhouse Use
Botran®	Cabrio®	Acrobat®
Champ®	chlorothalonil[2]	Actigard®
Contans®	Endura®	Agri-Fos®
Cuprofix®	Flint®	Agri-mycin®
Dithane®	Forum®	Aliette®
Fontelis®	Merivon®	Curzate®
Kocide 2000®	Presidio®	Gavel®
Kocide 3000®	Priaxor®	Gem®
Luna Privilege®[3]	Pristine®	Inspire Super®
Previcur Flex®	Quadris®	Kocide 20/20®
Procure®	Quadris Opti®	Luna Experience®
Procure 480SC®	Quilt®	Luna Sensation®
Ranman®[4]	Reason®	Luna Tranquility®
Scala®	Ridomil®	Manzate®
Terrachlor®[5]	Satori®	Monsoon®
	Vapam®	Omega®
	Zampro®	Penncozeb®
		Phostrol®
		Quadris Top®[6]
		Quintec®
		Rally®
		Revus®
		Revus Top
		Rovral®
		Serenade Max®
		Switch®
		Tanos®
		Toledo®
		Torino®
		Ziram®

[1]For example, a tomato grower in the field can use any of the products listed in the entries on pages 127-128 to treat early blight of tomato. In a greenhouse, the same grower could not use Cabrio®, any product with chlorothalonil, Endura®, Quadris®, or Quadris Opti® (these product labels prohibit greenhouse use). In the greenhouse, the grower may use the other products because the label either specified that it could be used (mancozeb products such as Dithane®, or Scala®), or the label did not mention use in the greenhouses (mancozeb products such as Manzate®/Penncozeb®, or Gavel®, Inspire Super®, Revus Top®, Tanos®, Switch®, or Ziram®).

[2]All products with the active ingredient chlorothalonil are prohibited in the greenhouse including Bravo®, Echo®, and Equus®.

[3]Labeled only for greenhouses of 10 acres or more.

[4]For use on tomato transplants only.

[5]Use only on bedding plants grown in containers.

[6]Do not use for transplant production.

Using a Plant Diagnostic Lab

The best way to identify insects, plants and plant diseases, or diagnose plant and pest problems, is to send a sample to a diagnostic laboratory. The National Plant Diagnostic Network website (www.npdn.org) lists diagnostic laboratories by state and region. Contact individual laboratories for specific submission and fee information (see page 42-43).

To ensure an accurate diagnosis, it's important to collect and ship your specimens properly. Here are a few guidelines for collecting and shipping specimens to a diagnostic lab.

1. Collect fresh specimens. Send a generous amount of material, if available.
2. Ship specimens in a crush-proof container immediately after collecting. If holdover periods are encountered, keep specimen cool. Mail packages to arrive on weekdays.
3. Incomplete information or poorly selected specimens may result in an inaccurate diagnosis or inappropriate control recommendations. Badly damaged specimens are often unidentifiable and additional sample requests can cause delays.

Submitting Plant Specimens for Disease/Injury Diagnosis

Herbaceous Plants. For generally declining, wilting, or dying plants, send several whole plants showing a range of symptoms (early through more advanced) with roots and adjacent soil intact. Dig up the plants carefully. Place roots and surrounding soil in a plastic bag and fasten it to the base of stem with a twist tie or string. *Do not* add water. Soil and attached roots of smaller specimens may also be secured in a double layer of heavy-duty aluminum foil pressed around the root system. Wrap the plants in dry newspaper and place in a crush-proof container for shipment.

Leaves/fruit/tubers. When localized infections (such as leaf spots or fruit rots) are suspected, send specimens representing early and moderate stages of disease. Press leaves flat between newspaper and cardboard and wrap fruits or tubers in dry newspaper. Place in a crush-proof container for shipment.

Submitting Insect Specimens

Package insects carefully so they aren't damaged when they arrive at the lab. Separate and label the specimens if you send more than one type in the same package. Provide the appropriate information for each specimen.

Tiny or Soft-bodied Specimens. Submit such specimens (aphids, mites, thrips, caterpillars, grubs, spiders) in a small, leak-proof bottle or vial of 70 percent alcohol. Rubbing alcohol (isopropyl) is suitable and readily available. *Do not* submit insects in water, formaldehyde, or without alcohol or they will ferment and decompose. Package carefully to assure vials do not break in shipment. Small insects found on leaves can also be submitted on the plant material. Wrap several leaves in dry newspaper, and then seal in a plastic bag to prevent insects from escaping.

Hard-bodied Specimens. Submit such specimens (flies, grasshoppers, cockroaches, wasps, butterflies, beetles) dry in a crush-proof container. *Do not* tape insects to paper or place them loose in envelopes.

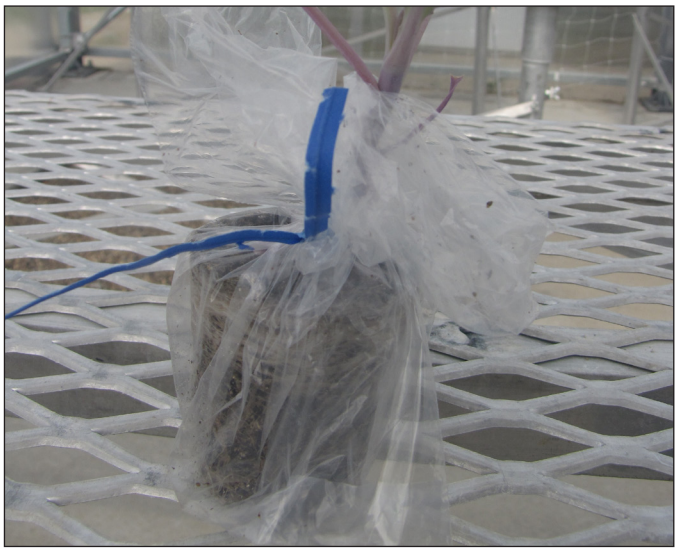
Submitting Samples for Nematode Analysis

If you suspect a nematode problem, contact clinics for state-specific submission information (see pages 42-43).

In general nematode identification requires collection of at least one quart of soil from the root zone of affected plants. Include roots if the plants are actively growing.

Place the entire sample in a plastic bag. *Do not* add water or allow it to dry out. Protect the sample from extreme heat (for example, don't leave samples inside a parked vehicle in direct sunlight). It is often helpful to collect a second, similar sample from a nearby area where plant growth appears normal.

Attach a label, note, or tag identifying the sample to the outside of each bag or package.



The root system of this plant has been bagged so diagnosticians can examine the roots as well as its foliage upon arrival at the diagnostic laboratory. When submitting samples to a lab, remember to attach a label, note, or tag identifying the sample to the outside of each bag or package.

Selected University Diagnostic Labs

Illinois

Univeristy of Illinois Plant Clinic
S-417 Turner Hall
1102 S. Goodwin Avenue
University of Illinois
Urbana, Illinois 61801
(217) 333-0519

web.extension.illinois.edu/plantclinic
www.facebook.com/UofIPlantClinic

Contact:

Suzanne Bissonnette
sbissonn@illinois.edu
(217) 333-2478

Indiana

Plant and Pest Diagnostic Laboratory
Purdue University
LSPS 101
915 W. State Street
West Lafayette, IN 47907-2054
(765) 494-7071
Fax: (765) 494-3958

ppdl.purdue.edu

Contacts:

Tom Creswell
creswell@purdue.edu

Gail Ruhl
ruhlg@purdue.edu

Iowa

Iowa State University Plant and Insect Diagnostic Clinic
327 Bessey Hall
Iowa State University
Ames, IA 50011
(515) 294-0581
Fax: (515) 294-9420

www.plantpath.iastate.edu/pdc

Contact:

Laura Jesse
ljesse@iastate.edu

Kansas

Plant Disease Diagnostic Lab
Extension Plant Pathology
4032 Throckmorton Hall
Kansas State University
Manhattan, KS 66506-5504
(785) 532-5810
Fax: (785) 532-5692

www.plantpath.ksu.edu/p.aspx?tabid=49

Contact:

Judith O'Mara
jomara@ksu.edu

Minnesota

Plant Disease Clinic
Department of Plant Pathology
495 Borlaug Hall
1991 Upper Buford Circle
University of Minnesota
St. Paul, MN 55108
(612) 625-1275
Fax: (612) 625-9728

pdc.umn.edu

Contact:

Brett Arnaz
aren0058@umn.edu

Missouri

Plant Diagnostic Clinic
28 Mumford Hall
Columbia, MO 65211
(573) 882-3019
plantclinic.missouri.edu
Contact:

Patti Wallace
(573) 882-3019
wallacepk@missouri.edu

Plant Nematology Lab
23 Mumford Hall
University of Missouri
Columbia, MO 65211
(573) 884-9118
Fax: (573) 882-0588
soilplantlab.missouri.edu/nematode

Contact:

John Dempsher
DempsherJ @missouri.edu

Ohio

C. Wayne Ellett Plant and Pest Diagnostic Clinic
Ohio State University
8995 E. Main St., Bldg. 23
Reynoldsburg, OH 43068
(614) 292-5006
Fax: (614) 466-9754

ppdc.osu.edu

Contact:

Nancy Taylor
taylor.8@osu.edu or ppdc@cfaes.osu.edu

Farm Labor Law Information

For information about the Immigration and Reform Act and current related farm and labor laws that specify employer responsibilities and seasonal agricultural worker status, contact the resources below:

Federal

Office of Special Counsel, Washington, D.C.
Employer Information: (800) 255-8155.
U.S. Citizenship and Immigration Services
(800) 375-5283
(800) 767-1833 (TTY)
www.uscis.gov

Illinois

Travel Control Section, Immigration and Naturalization Service
10 W. Jackson
Chicago, IL 60604

(Migrant Farm Workers and Farm Labor) Department of Labor
310 S. Michigan Ave.
Chicago, IL 60604
(312) 793-2804

Indiana

Immigration and Naturalization Service (INS)
950 N. Meridian Street, Room 400
Indianapolis, IN 46204-3915

Indiana Department of Workforce Development
Indiana Government Center South
10 North Senate Avenue
Indianapolis, IN 46204
1-888-WORKONE
workone@dwd.in.gov
www.IN.gov/dwd/

Migrant Farmworkers Project
Krin Flaherty
105 E. Jefferson Blvd., Suite 600
South Bend, IN 46601
(800) 288-8121 (toll free)
(574) 234-8121

Iowa

Iowa Department of Workforce Development
Attn: John McDonald, Monitor Advocate
150 Des Moines St.
Des Moines, IA 50309
(515) 281-9336

Kansas

Kansas Department of Commerce Workforce Compliance and Oversight, Legal
Attn: Jenny Tavares, Monitor Advocate
Kansas Department of Commerce
1000 SW Jackson St., STE 100
(785) 296-5014
jtavares@kansascommerce.com

Minnesota

Immigration and Naturalization Service (INS)
2910 Metro Dr.
Bloomington MN 55425
Minnesota Labor and Industry Department
443 Lafayette Rd.
St. Paul, MN 55155

Missouri

Missouri Department of Economic Development, Division of Workforce Development
421 E. Dunklin St.
Jefferson City, MO 65101
(573) 751-3773
(573) 751-9571

Ohio

Peggy Kirk Hall
25C Agricultural Admin. Bldg.
2120 Fyffe Road
Columbus, OH 43210
(614) 247-7898

On-farm Food Safety

Good Agricultural Practices (GAP) present a set of guidelines that can prevent or reduce the risk of potential contamination of vegetables in the field and during post-harvest production. Foodborne pathogens associated with fresh produce include *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., Norovirus, hepatitis A virus, *Cyclospora cayatanensis*, and *Listeria monocytogenes*. To reduce the risk of foodborne illness, vegetable growers should adopt GAPs, paying particular attention to water management.

Water Management

Water is essential for crops, but it also is an excellent growth medium for microorganisms. Water is a major source of contamination in crop production. Growers use water for irrigation, washing products, hydro-cooling, icing, applying fertilizers and pesticides, preparing soil amendments, and washing equipment and facilities. It is important to make sure that any water that comes in contact with the crop is microbiologically clean.

Growers should carefully monitor irrigation water and processing water.

Irrigation Water

The quality and safety of irrigation water determines the quality and safety of the produced crop. And the safety of the water depends on its source: is it ground water or surface water. Pathogens can be introduced into irrigation water through manure runoff from animal production facilities, sewage runoff from treatment facilities or septic systems, or directly from wildlife. Extreme rainfall, manure spills, or human waste can increase the probability of contamination occurring.

Ground water is less likely to be contaminated due to the natural filtration through soil layers. Well water when used directly bears a relatively low contamination risk, provided that well walls are properly constructed and well maintained. Still, there is a potential for contamination if animals frequent the area surrounding the wellhead or sewage leaks into the recharge area. If well walls are fortified with clean soil, with no gaps between the well and soil, runoff will flow away from well.

Surface water (such as ponds, creeks, and rivers) can easily be contaminated by runoff or wildlife. Surface water also has more variable microbial quality and the level of contamination may rapidly change.

If irrigation water comes from a creek or river, consider using a settling pond to control the microbial load. In settling ponds, large particles that contain microorganisms will settle at the bottom. You can also communicate with neighboring livestock producers and work on ways maximize the distance between livestock and water bodies used for irrigation or other crop production practices like spraying. When possible, build natural buffer zones around water to prevent runoffs.

The quality of water in ponds depends on the original source and on how well the pond is protected from contamination from runoff and wildlife. Ponds filled from groundwater sources have higher quality water than those filled from rivers or ditches. To protect ponds, there are several steps growers can take:

1. Construct ponds well away from apparent sources of contamination such as livestock facilities and pastures, composting pads, and sewage systems.
2. Fence ponds to prevent wildlife and domestic animals from entering and contaminating the water and surroundings.
3. Redirect runoff to flow away from the pond by building a bank or channel.
4. Establish vegetation buffer zones around ponds to filter runoff before it gets into the pond.

Take special precaution when surface waters may contain sediment and high microbial contamination loads washed in by heavy rain. Remember that bird and rodent feces or dead animals can contaminate rainwater storage tanks. And if improperly treated, recycled municipal wastewater presents a high contamination risk.

To prevent crop contamination, be aware of the microbial quality of water. Periodically test water for the presence of microorganisms that indicate fecal contamination and *E. coli*. The frequency of testing depends on the nature and extent of contamination. The critical limits for *E. coli* depends on the intended use of the water and time to harvest. Currently accepted guidelines call for no more than 126 generic *E. coli* colony forming units (cells) per 100 milliliters of water intended for pre-harvest uses. *E. coli* should be below detectable limits for post-harvest uses (product cleaning, product cooling, etc.)

Growers should also monitor other potential sources of microbial contamination, including application methods, application timing (how close to harvest), and vegetable types. These factors are often interrelated and have to be considered in a combination.

There are various water application methods, including flood irrigation, spray irrigation, drip/trickle irrigation, and sub-irrigation. Flood irrigation may easily spread fecal runoffs and presents a high food safety risk. Drip irrigation comes in contact only with the roots, so the risk of contamination is limited.

When choosing the application method, consider the crop. Vegetables grown closer to the ground are exposed to a greater risk since they can easily contact the contaminant, either through splashed soil or manure during irrigation. Products that are eaten fresh are also at a higher risk, as are vegetables that have large leaf surfaces (such as leafy greens) and vegetables that can trap and hold water.

Processing Water

Water is used in many processing operations, including washing produce, cooling, top-icing, and transferring product with flumes. Wash water is a potential source of contamination. Washing fresh produce with contaminated water is one way pathogens can be introduced to and spread throughout a harvest lot. Wash water that is not clean and sanitary can easily transfer pathogens from contaminated to noncontaminated produce.

To prevent contamination, treat wash water. There are a number of chemical and nonchemical sanitizers, including chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. Your water treatment choice depends on the application and type of product. Seek sound technical advice before investing in a system. Any treatment should be labeled for the intended use. See Table 18 for a list of EPA-registered products for use in produce wash water.

Chlorine is the most common used sanitizer. It reacts with all organic compounds, including bacterial cells that are present in water. However, dirty wash water quickly neutralizes chlorine and render it ineffective against microorganisms. Chlorine is most active when water pH is 6.8-7. Add citric or other organic acids approved for contact with food to reach this pH.

Chlorine's effectiveness depends on a number of factors, including the initial microorganism load, water temperature, produce type, and contact time between produce and chlorinated water. Monitor chlorine levels to ensure optimal activity. Chlorine activity is optimal when it has an oxidation reduction potential (ORP) of 650 mV or more and a pH 6.8-7.0. You can monitor ORP and pH with a handheld instrument.

Table 18: Sanitizers Approved for Wash or Process Water

These sanitizing agents have been labeled by the U.S. EPA used for use in wash or process water for vegetables. Individuals must check with their respective states to determine if a state label is available.

Product Name	Active Ingredient	Company	EPA Reg. No.
Agclor®	sodium hypochlorite	Decco	2792-62
Anthium Dioxcide®	chlorine dioxide	International Dioxcide	9150-2
Antimicrobial Fruit and Vegetable Treatment®	lactic acid	Ecolab	1677-234
Biosafe Disease Control RTU®	hydrogen peroxide	Biosafe Systems	70299-9
Biosafe Fruit & Vegetable Wash®	hydrogen peroxide	Biosafe Systems	70299-9
BioSide HS-15%®	peroxyacetic acid	Enviro Tech	63838-2
Biotrol 150®	peroxyacetic acid	U S Water Services	63838-2-71675
Bromide Plus®	sodium bromide	Clearon	8622-49-69470
Bulab 6040®	sodium bromide	Buckman Laboratories	1448-345
Busan 1167®	sodium bromide	Buckman Laboratories	1448-345
Carnebon 200®	chlorine dioxide	International Dioxcide	9150-3
Chlor San 1050®	sodium hypochlorite	Chemstation Of Northern Indiana	67649-20001-74373
Chlor-Clean 12.5®	sodium hypochlorite	Madison Chemical	550-198-110
Chlorine Liquefied Gas Under Pressure®	chlorine	Olin Chlor Alkali Products	72315-1
Clearitas 450®	sodium hypochlorite	Blue Earth Labs	87437-1
DicaSan PAA®	peroxyacetic acid	Dubois Chemicals	63838-1-3635
Enviroguard Sanitizer®	peroxyacetic acid	Rochester Midland	63838-1-527
Formula 308®	sodium hypochlorite	Garratt Callahan	33981-20002-8540
Hydroxysan PA No. 480®	peroxyacetic acid	Hydrite Chemical	63838-1-2686
Induchlor 70®	calcium hypochlorite	PPG Industries	748-296
K-Brom 40®	sodium bromide	Water Science Technologies	88714-3
KC-610®	peroxyacetic acid	Packers Chemical	63838-1-63679
Madison Oxy-San Acid Sanitizer Disinfectant®	peroxyacetic acid	Madison Chemical	63838-13-110
Oakite Liquid Bactericide®	sodium hypochlorite	Chemetall	9359-2-1020
Oxine®	chlorine dioxide	Bio-Cide	9804-1
Oxywave®	peroxyacetic acid	Madison Chemical	63838-1-110
Peraclean 15®	peroxyacetic acid	Evonik	54289-4
Peraclean 5®	peroxyacetic acid	Evonik	54289-3
Perasan A®	peroxyacetic acid	Enviro Tech	63838-1
Peroxy-Serve 5®	peroxyacetic acid	Zep	63838-1-1270
Premium Peroxide II®	peroxyacetic acid	West Agro	63838-1-4959
SaniDate 12.0®	peroxyacetic acid	Biosafe Systems	70299-8
Sno-Glo Bleach®	sodium hypochlorite	Brenntag Mid-South	6785-20002
Sobr2®	sodium bromide	Buckman Laboratories	1448-345
Sodium Hypochlorite-12.5 Bacticide®	sodium hypochlorite	Olin Chlor Alkali Products	72315-6
Sodium Hypochlorite 12.5%®	sodium hypochlorite	Alexander Chemical	7151-20001
Sodium Hypochlorite Solution 12.5%®	sodium hypochlorite	KA Steel Chemicals	33981-20001
Sysco Classic Germicidal Ultra Bleach®	sodium hypochlorite	Sysco	70271-13-29055
Tsunami 100®	peroxyacetic acid	Ecolab	1677-164
Vertex Concentrate®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-10®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-12®	sodium hypochlorite	Vertex Chemical	9616-7
Vertex CSS-5®	sodium hypochlorite	Vertex Chemical	9616-10
VigorOx 15 F&V®	peroxyacetic acid	FMC	65402-3
VigorOx SP-15 Antimicrobial Agen®	peroxyacetic acid	FMC	65402-3
WSU Sodium Hypochlorite 12.5%®	sodium hypochlorite	Water Solutions Unlimited	33981-20001-83327
Zep Fruit & Vegetable Wash®	peroxyacetic acid	Zep	63838-1-1270

More information about chlorine-based systems and ORP is available in*Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control and Documentation*, University of California publication 8149, available from ANRCatalog, anrcatalog.ucdavis.edu.

More information about GAPs is available in:

- Food Safety for Fruit and Vegetable Farms, ag.purdue.edu/hla/foodsafety/Pages/default.aspx.
- U.S. FDA, www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm.
- *Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables*, U.S. FDA, www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/produceplantproducts/ucm064458.htm.
- GAPsNET, Cornell University, www.gaps.cornell.edu.
- *On-farm Food Safety: Guide to Good Agricultural Practices (GAPs),* Iowa State University Extension publication PM1974a, available from the Extension Online Store, store.extension.iastate.edu.
- Good Agricultural Practices, U.N. Food and Agriculture Organization, www.fao.org/prods/GAP.

Insect Management Strategies

Effective insect and mite management involves at least seven steps:

1. Preventive practices.
2. Properly identifying key pest insects and mites, and beneficial organisms.
3. Selecting and using preventive pest management practices.
4. Monitoring the current status of insect and mite populations.
5. Determining the pest's economic loss potential
6. Selecting the proper pest control option.
7. Evaluating the effectiveness of previously used control options.

Preventative Insect Management Practices

There are a number of practices that can reduce insect numbers before you actually see the insects in the field. Often, decisions about these practices must be made based on past experience with the insect rather than current knowledge of the severity of the infestation. Many of these practices are good management practices for weeds and diseases as well, so they can easily be incorporated into an overall insect management program.

Resistant Varieties: There are not many vegetable varieties that have been bred for insect resistance. However, there are some varieties of cabbage that are resistant to onion thrips. Selection of sweet corn varieties that have husks that completely cover the ear tip and fit tightly around the ear can reduce the amount of corn earworm damage. Short season varieties of potatoes should be grown when possible to give Colorado potato beetles less time to feed and reproduce. This is not resistance, but it is a method that growers can use to reduce insect damage by varietal selection.

Crop Rotation: Rotating crops can reduce the severity of a number of pest problems. Rotating potato fields can greatly increase the amount of time it takes Colorado potato beetles to colonize a field, thereby reducing the time the beetles have to increase to damaging levels. Don't plant crops that are susceptible to wireworm or white grub damage in fields that were previously in sod or heavily infested with grassy weeds. In addition, it is a good idea not to plant cabbage or onions next to small grain fields, because onion thrips build up to very high levels in small grains and may move into cabbage or onions when the small grains dry down or are harvested.

Crop Refuse Destruction: Destroying the plant residue after harvest can reduce the damage experienced the next year from a number of insects. Destroying squash and pumpkin vines after completion of harvest can greatly reduce the overwintering population of squash bugs and squash vine borers. Early vine killing in potatoes will reduce the potato beetle populations for the following year.

Tillage: Fields that receive reduced amounts of tillage or have some sort of grass windbreaks are often more susceptible to damage from insects such as cutworms and armyworms. These cultural practices may have other advantages that outweigh the potential insect problems, but growers should be aware of the potential for increased insect activity.

Time of Planting: Because insects tend to become active at specific times each year, varying the time of planting can sometimes help prevent serious insect problems. Corn earworms and fall armyworms are usually a much more serious problem on late-planted sweet corn. If the option is available, planting sweet corn so that it has no green silks before large numbers of earworm moths are

flying can reduce earworm problems. Root maggots are usually more serious during cool, wet weather. Waiting until soil temperatures are adequate for rapid plant growth will help reduce maggot problems.

Biological Control: Conserving natural enemies is one aspect of biological control that can effectively reduce pest populations and damage. This can be accomplished in several ways, but the most important is reducing the number of insecticide applications. Each time a spray is applied, more predators and parasites are killed. When deciding to use an insecticide, you should consider the impact that application will have on beneficial insects. *Bacillus thuringiensis* products, for example, do not harm beneficial insects.

Proper Identification

Properly identifying pests is the foundation on which a good insect management program is built. If the pest is not properly identified, the chances of selecting the correct control strategies are greatly diminished. Many insects and mites can be correctly identified simply because they are encountered so often. However, it never hurts to back up your knowledge base with some reference materials. Your county Extension office has a number of bulletins available that will help you properly identify insect pests. There also are a number of good books available with color photographs of many of the common insect pests. Most entomologists don't like to admit it, but we often identify unfamiliar insects by comparing them to pictures in a book.

As will be discussed in the next section, beneficial organisms can be important components of an effective insect management program. Being able to distinguish the good guys from the bad guys may help you avoid unnecessary and possibly disruptive pesticide sprays. Some common beneficial organisms all growers should be able to identify include lady beetle larvae and adults, lacewing larvae and adults, and syrphid fly larvae.

In addition to proper identification, it is helpful to know as much as possible about the insect's biology. All growers should know the difference between insects with incomplete metamorphosis and those with complete metamorphosis.

Insects with incomplete metamorphosis have juvenile stages — called nymphs — that resemble the adults, except that they are smaller and don't have wings. The feeding behavior is usually the same for nymphs and adults. For example, squash bugs are an insect with incomplete metamorphosis.

Insects with complete metamorphosis have a larval stage that is completely different in appearance from the adult. They also have an intermediate stage, known as a pupa, between the larval and adult stages. Larvae never have wings and are not capable of reproducing. Larvae go through a series of molts (shedding their skins) in order to grow. Larvae and adults frequently, although not always, feed differently. Adult insects never grow, so little beetles don't grow up to be big beetles. For example, caterpillars are larvae. In their adult stage, these larvae become moths or butterflies.

For important insect and mite pests, it also is helpful to know the overwintering stage, life cycle length, and number of generations per year that can be expected. Again, most of this information can be found in Extension bulletins.

Monitoring

Vegetable growers must make insect and mite pest management decisions on an almost daily basis during the growing season. To make the best decisions, it is often useful to have information regarding the current status of a pest's population. This can be accomplished through some sort of sampling or monitoring program. There are several methods to monitor insect populations.

Pheromone traps can be used to determine when moths are flying. This information can be used in several ways. First, catching moths in the trap can alert growers to begin looking for the pest in the field. This can save time because the grower won't be looking for the pest before it is present. Second, pheromone trap catches can be used to time insecticide applications. Third, for some pests, such as corn earworms, the need to spray can be determined from the number of moths caught in the trap. Pheromones are available for many of the caterpillar pests of vegetables.

The most common method for monitoring insects is by scouting fields. Scouting can be formal, such as counting insects on a given number of plants throughout the field, or it can be informal, with the grower walking through the field and looking for insects on the plants. Formal scouting may be more accurate, but the most important thing is for growers to regularly walk their fields looking for insects or insect damage. Some pests, such as mites, may require the use of a hand lens to see. Others may require the use of equipment such as a sweep net or a beat cloth. Most can be monitored just by close inspection of the plants. Regular (weekly) monitoring will allow growers to make informed management decisions.

Determining the Potential for Economic Loss

Unfortunately, we do not have economic thresholds for many vegetable insect pests. Whenever possible, we have listed the best thresholds available along with control options in the crop-specific sections of this manual. Although some of these estimates have not been verified by research in each state, they have been derived from scientific research or extensive observations. Growers may wish to adjust these thresholds based on past experience. Extension bulletins also are useful sources of information regarding potential losses from insects. Growers should remember that some crops, such as snap beans and potatoes, can suffer a great deal of defoliation before there is any effect on yield. Sometimes, plants with considerable amounts of insect damage will yield as well as plants that have no insect feeding. If the pest is one that feeds on the marketable portion of the plant, then less damage can be tolerated.

Before considering a management option, it's important to first correctly identify the insect responsible for plant feeding. This is a European corn borer attacking a pepper fruit.

Proper Selection of a Pest Control Option

In vegetable crops, the selection of a control option during the growing season usually means doing nothing or selecting a pesticide. Although we always encourage growers to read and follow label directions, the one area where the label is not necessarily the best source of information is concerning which insects the insecticide will control. The insecticides recommended in this book for control of various pests are listed because they are legal to use and because they have been found to be effective by the authors. Consider insecticide costs, application costs, relative effectiveness, gain in profits that can be expected from the application, whether it will control other pests, and how it will affect predators, parasites, and pollinators. Growers should refrain from "revenge spraying," that is, spraying after the damage is already done. At that point, spraying is a waste of money and may actually increase pest damage by killing beneficial insects.

Evaluation

Growers should always evaluate the effectiveness of a pest control action. Inspecting the field a couple of days after an insecticide is applied will help the grower determine the necessity for additional control measures in that field, as well as provide information about the insecticide's effectiveness for future reference. Growers should pay attention to whether the insecticide killed all stages of the pests or if only small larvae or nymphs were killed. They should also notice the effects on other pests in the field and on beneficial insects.

Resistance Management

It is important to occasionally rotate products with different modes of action in order to reduce the potential of insect and mite populations developing resistance to products with specific modes of action. A pesticide's mode of action is how it affects the metabolic and physiological processes in the pest (in this case, the pests are insects or mites). Many product labels contain resistance management information or guidelines that will help vegetable growers determine which products they should rotate with others. For more information associated with rotating different modes of action, contact your state or regional extension entomologist.

Table 19: Preharvest Intervals (Days) and Re-Entry Intervals (Hours) for Insecticides/Acaracides Registered for Use on Midwest Vegetables 2015[1]

	Acramite®	Actara®	Admire®	Agri-Mek®	Asana®	Assail®	*Bacillus thuringiensis*	Baythroid®	Belay	Brigade®	Coragen®	Cryolite®/Kryocide®	Danitol®	Dimethoate®	Entrust®	Fulfill®	Intrepid®	Lannate®	Larvin®	Lorsban®	Malathion®	Mustang MAX®	Neemix®	Oberon®	Orthene®	Platinum®	Pounce®/Ambush®	Proclaim®	Provado®	Radiant®	Rimon®	Sevin®	Synapse	Voliam Flexi®	Voliam Xpress	Warrior®
Asparagus							0				1			180	60	170		1		X	1		0				1			60		1				
Beet		7	21				0			1	1				3		14	0			7	1	0			X			7	7		7				
Broccoli		0	X		3	7	0	0	21	7	3	7	7	7	1	7	1	3	7	X	2	1	0	7		30	1	7	7	1	7	3	1	3	3	1
Brussels Sprouts		0	X			7	0	0	21	7	3	7	7	10	1	7	1	3		X	2	1	0	7	14	30	1	7	7	1	7	3	1	3	3	1
Cabbage		0	X		3	7	0	0	21	7	3	14	7		1	7	1	1	7	X	7	1	0	7		30	1	7	7	1	7	3	1	3	3	1
Cantaloupe	3	0	21	7	3	0	0	0	21	3	1	14	7	3	3	0	3	X			1	1	0	7		30	0			3	1	3	1	1	1	1
Carrot		7	21		7		0	0		21	1				3		14	1			7		0			X			7	3		7				
Cauliflower		0	21		3	7	0	0	21	7	3	7	7	7	1	7	1	3	7	X	2	1	0	7	14	30	1	7	7	1	7	3	1	3	3	1
Celery		7	45	7		7	0	0	21		1			7	1	7	1	7	14		7	1	0		21	30	1	7		1		14	1	7		
Chinese Cabbage		7	X		3	7	0	0	21	7	3		7		1	7	1	10		X		1	0	7		30	1	7	7	1	7	14	1	7	3	1
Collard		7	X		7	7	0	0	21	7	3	14			1	7	1	10		X	7	1	0	0		30	1	14	7	1		14	1	7		
Cucumber	3	0	21	7	3	0	0	0	21	3	1	14	7		1	0	3	X			1	1	0	7		30	0			1	1	3	1	1	1	1
Eggplant	3	0	X	7	7	7	0	7	21	7	1	14	3		1	0	1	5			3	1	0	1		30	3	7	0	1	1	3	1	1	5	5
Endive		7	X	7		7	0	0	21		1			14	1	7	1	10	14		7	1	0	7		30	1	7	7	1		14	1	7		
Green Onion			21			7	0			1	1				1		1	7			3	7	0						1							
Head Lettuce		7	X	7		7	0	0	21	7	1	14			1	7	1	X	14		14	1	0	7	21	30	1	7	7	1		14	1	7	1	1
Kale		7	X			7	0	0	21	7	3			14	1	7	1	10		X	7	1	0			30		14	7	1		14	1	7		
Kidney Bean			X		21	7	0	7		14	1			0	X		7	X		X		X	0		14				7	X	1	X				X
Leaf Lettuce		7	X	7		7	0	0	21		1	14		14	1	7	1	X	14		14	1	0	7		30	1	7	7	1		14	1	7	1	1
Lima Bean	3		X			7	0			3	1			0	X		7	X		X		X	0		1				7	3	1	X				X
Mint	7	7		28			0				3				7		14	14		90	7		0		14					7				7		
Mustard		7	X		7	7	0	0	21	7	3			14	1	7	1	10			7	1	0	7		30		14	7	1		14	1	7		
Okra	3		X				0			7	1				1		1				1	1							0	1		3	1			
Onion Bulb			21			7	0				1				1			7		X	3	7	0				1			1						14
Parsley		7	X	7		7	0	0	21		1				1	7	1	10	14		7	1	0	7		30	1	7	7	1		14		7		
Parsnip		7	21				0				1				3		14				7		0			X			7	3		7	1			
Peas			X		3		0			3			7	0	X		7	1			3		0						7	X		X				X
Pepper	3	0	X	7	7	7	0	7	21	7	1	14	3	0	1	0	1	3			3	1	0	1	7	30	3	7	0	1	1	3	1	1	5	5
Potato		14	X	14	7	7	0	0	14	21	14	0		0	7	14		6			0	1	0	7		X	14		7	7	14	7		14	14	7
Pumpkin	3	0	21	7	3	0	0	0	21	3	1	14	7		3	0	3				1	1	0	7		30	0			3	1	3	1	1	1	1
Radish		7	21		7		0	0		21	1						14			X	7		0			X			7	3		7				
Rhubarb		7	45	7		7	0	0	21	7	1				1	7	1		14			1	0			30	1	7		1		14	1	7		
Snap Bean	3		X		3	7	0			3	1			0	X		7	X		X	0	X	0		14				7	3	1	X				X
Spinach		7	X	7		7	0	0	21	40	1				1	7	1	7	14		7	1	0	7		30	1	7	7	1		14	1	7		
Summer Squash	3	0	21	7	3	0	0	0	21	3	1	14	7		3	0	3	X			1	1	0	7		30	0			3	1	3	1	1	1	1
Sweet Corn					1		0	0		X	1				1		3	0	0	21	5	3	0	5			1			1	1	2			1	1
Sweet Potato		14	X			7	0	0	14	21	1				7	14	7			125	0	1	0	7		X	7		7	7	14	7		14	14	7
Tomato	3	0	X	7	1	7	0	0	21	1	1	14	3	7	1	0	1	1			1	1	0	1		30	0	7	0	1	1	3	1	1	5	5
Turnip		7	X		7		0	0	21	21	1			14	3	7	14	10		X	1	1	0	7		X	1		7	3			1			
Watermelon	3	0	21	7	3	0	0	0	21	3	1	14	7	3	3	0	3	X			1	1	0	7		30	0			3	1	3	1	1	1	1
Winter Squash	3	0	21	7	3	0	0	0	21	3	1	14	7		3	0	3				1	1	0	7		30	0			3	1	3	1	1	1	1
Re-Entry Intervals (hours)	12	12	12	12	12	12	4	12	12	12	4	12	24	X	4	12	4	48	48	X	X	12	12	12	24	12	12	12	12	4	X	12	12	12	24	24

X=check label for details.

[1]Check label directions before applying any of these pesticides.

Table 20: Common Names of Registered Insecticides and Acaricides

Common Name	Trade Names	Producers	Formulations1
abamectin	Agri-Mek®	Syngenta	0.15EC, SC
acephate	Orthene®	Amvac	75S, 90S, 97
acetamiprid	Assail®	UPI	30SG
azadirachtin	Neemix®	Certis	
azadirachtin + pyrethrins	Azera®	MGK	
Bacillus thuringiensis var. *aizawai*	Agree®, Xentari®	Certis, Valent,	38%
B. thuringiensis var. *kurstaki*	Biobit®, Dipel®, Javelin®, Lepinox®	Valent, Certis, DuPont, others	ES, WP, 4L ES, 10G, WG, F, WP, P, WPG
bifenazate	Acramite®	Chemtura	50WS, 4SC
bifenthrin	Brigade®, Capture®	FMC	2EC, 1.15G, WSB
carbaryl	Sevin®	Bayer, Wilbur-Ellis	50WP, 80S, 5B, XLR PLUS
chlorantraniliprole	Coragen®	DuPont	1.67SC
chlorantraniliprole + lambda-cyhalothrin	Voliam Xpress®	Syngenta	1.25EC
chlorantraniliprole + thiamethoxam	Voliam Flexi®	Syngenta	40WDG
chlorpyrifos	Lorsban®	Dow AgroSciences, Gowan	4E, 15G, 50W
clothiandin	Belay®	Valent	2.13, 50WPG
cyantraniliprole	Exirel®	DuPont	0.83
cyfluthrin	Aztec®, Baythroid®	Bayer	2.1G, 1 EC
cyhalothrin	Warrior®	Syngenta	1CS
cypermethrin	Ammo®	FMC	2.5EC
cyromazine	Trigard®	Syngenta	75WP
diazinon	Diazinon®	Helena, MANK, Loveland	50WP, AG500, 600WBC
dimethoate	Dimethoate®	Gowan, Helena, others	4EC, 2.67 EC
emamectin	Proclaim®	Syngenta	5WDG
endosulfan	Endosulfan®	Drexel	3EC
esfenvalerate	Asana XL®	DuPont	0.66 EC
fenpropathrin	Danitol®	Valent	2.4EC
flubendiamide	Synapse	Bayer	24WG
imidacloprid	Admire®	Bayer	4F, 1.6F
indoxacarb	Avaunt®	DuPont	30WDG
malathion	Malathion®	many	many
methamidophos	Monitor®	Valent, Bayer	4F
methomyl	Lannate®	DuPont	90WSP, 2.4WSL
methoxyfenozide	Intrepid®	Dow AgroSciences	2F
novaluron	Rimon®	Chemtura	0.83EC
oxamyl	Vydate®	DuPont	2WSL
permethrin	Ambush® Pounce®	AMVAC, FMC	25WP, 2EC, 1.5G, 0.5B
phorate	Thimet®	Amvac	20G
phosmet	Imidan®	Gowan	70WP
pymetrozine	Fulfill®	Syngenta	50WG
pyriproxyfen	Knack®	Valent	0.86EC
sodium alumino fluoride	Cryolite®, Kryocide®	Gowan, Cerexagri	96%, 50D
spinetoram	Radiant®	Dow AgroSciences	1SC
spinosad	Entrust®	Dow AgroSciences	2SC
spiromesifen	Oberon®	Bayer	2SC, 4SC
sulfoxaflor	Transform®	Dow AgroSciences	50%
thiamethoxam	Actara®, Platinum®	Syngenta	25WDG, 75SG, 25G
thiodicarb	Larvin®	Bayer	3.2
tolfenpyrad	Torac®	Nichino America	1.29
zeta-cypermethrin	Mustang MAX®	FMC	0.8EC, 1.5EW
zeta-cypermethrin + bifenthrin	Hero®	FMC	EW

1A=aqueous, B=bait, CS=capsule suspension, D=dust, E or EC=emulsifiable concentrate, ES=emulsifiable suspension, EW = oil in water immersion, F=Flowable, G=granules, L=Liquid, S or SP=sprayable powder, SC=soluble concentrate, W or WP=wettable powder, WDG=water-dispersible granules,WSL=water soluble liquid, WSP=water soluble powder, WG=wettable granule.

Plant Parasitic Nematode Management Strategies

Disease Diagnosis

Plant parasitic nematode management hinges on detection and population density estimation. Before selecting a field for vegetable production, submit a soil sample to a lab with a trained nematologist to analyze the soil for the presence and quantity of plant parasitic nematodes. Root-knot nematodes (*Meloidogyne* spp.) and soybean cyst nematodes *(Heterodera glycines)* are the most important nematode pests commonly found in the Midwest.

Disease-resistant Varieties

Resistance to *Meloidogyne incongnita* is available with the Mi gene in tomato, but few other vegetable crops presently have resistant genes for root-knot nematodes. Nematode resistance in tomatoes is indicated by the "N" designation. Resistant varieties should be used whenever possible to reduce yield loss. It is important to have multiple disease resistance genes when more than one important pathogen is present in a field, such as with tomatoes where root-knot nematodes, Verticillium, and Fusarium can interact.

Crop Rotation

Plant parasitic nematodes overwinter in the soil or in association with plant material. Crop rotation and weed control are very important in managing plant parasitic nematodes. Root-knot nematodes have a very wide vegetable, field crop, and weed host range. Soybean cyst nematodes have a much narrower host range, but when both nematode species are present, a rotation ideal for soybean cyst nematode reduction may favor buildup of root-knot nematodes.

Other Cultural Practices

Adequate water and fertilizer can minimize plant parasitic nematode damage. Plant parasitic nematodes reduce the plant root system's ability to take up water and nutrients. Adequate water and fertilizer do not reduce nematode density but help plants to cope better with nematode damage, and might increase yield and reduce the symptoms of nematode damage.

Anything that moves soil can spread plant parasitic nematodes to other fields and within the same field. Thus, preventing infested soil and plant material from infesting fields will help with nematode management.

Chemical Control

Seedling diseases, root diseases, and vascular wilts caused by soilborne fungi and nematodes can be destructive problems in the field and greenhouse. Soil-applied fumigants or nematicides may help prevent serious losses to soilborne disease when combined with long-term management practices.

Soil fumigants are chemicals that are injected into the soil and emit toxic fumes that penetrate air spaces in the soil and kill microorganisms. Fumigants must be sealed into the soil with water or a plastic tarp to ensure that a lethal concentration and exposure time. Because fumigants are harmful to all living plants, a certain amount of time (from two weeks to two months) must pass between treatment and planting to avoid crop damage. Several nonfumigant nematicides are available for several vegetable crops. These generally are systemic compounds that also may provide good insect control.

A number of factors affect the performance of these products, including soil temperature, soil moisture, soil tilth, organic matter, soil type, and time of application. Consult the product label for specific details on safe handling and application methods.

A brief description of several common soil treatments is given in Table 21.

Table 21: Nematode Soil Treatments

Chemical	Fumigant/ Nematicide	Application	Plant Back Time	Crops	Comments
methyl bromide (RUP)	F	Preplant, tarped, or mulched for 24-48 hours.	10-14 days	most vegetables	Formulations with 98% methyl bromide and 2% chloropicrin are appropriate for nematode control.
Mocap®, ethroprop (RUP)	N	Soil only. Applied with water by soil injection, sprinkler system, flood irrigation, over soil surface with sprinkling can.		cabbage, sweet corn, cucumbers, potatoes, sweet potatoes, snap beans, lima beans	Mobile in sand soils. Crop injury can occur if used in furrow.
SMDC: sodium methydithio carbamate (Vapam®, etc.)	F	Preplant tarped. Don't enter within 48 hours.	14-21 days after treatment	general use fumigant	Vapam is more effective when applied with considerable water.
Vydate® (RUP)	N	Soil and foliage treatment.	NA	carrots, celery, cucurbits, eggplants, peppers, potatoes, sweet potatoes, tomatoes	Foliar applications are not effective for moderate and high populations of nematodes.
Telone® (RUP)	F	Soil treatment only.	2-3 weeks	most vegetables	Formulations with high percentages chloropicrin are needed to control soilborne fungal diseases.
Nemacur®, fenamiphos (RUP)	N	Soil treatment only.	NA	cabbage, Brussels sprouts, bok choy, okra, garlic	

F=fumigant
N=nematicide
RUP=restricted use pesticide

Belowground symptoms of root knot nematodes include roots with enlarged galls.

Weed Management Strategies

Weed management requires a multifaceted approach built on an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. The aim of any weed management strategy should be to manage the weed population so it is below a level that will reduce your economic return (economic threshold). It is important to consider the impact of weeds on yield and quality of the current crop, as well as the potential for increasing weed problems in future years if weeds go to seed. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop. In some instances, the cost of controlling weeds may be more than the economic return from any yield increase that season. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing, or to do the minimum required to prevent seed production and dispersal. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

The first step in weed management is to identify the weeds and understand their life cycles. Consult identification guides, such as *Weeds of the North Central States* (University of Illinois Agricultural Experiment Station Bulletin 772), for assistance. Weeds can be categorized by life cycles, and management strategies developed accordingly.

Annual weeds complete their life cycles in one year and reproduce solely by seeds. Annuals can be divided into summer or winter annuals, depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common vegetable crop weeds (e.g., barnyard grass, giant foxtail, common purslane, redroot pigweed, and common lambsquarters) are summer annuals.

Perennial weeds live for more than two years and can reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

Many nonchemical weed management methods are common sense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Cultural Practices

Farm practices should aim to establish a vigorous crop that competes effectively with weeds. This starts with land selection. A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially perennial weeds. Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields, and the least competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or in non-row crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used, inadvertently allow certain weeds to escape control. Rotation also affects the weed management tools at your disposal. Rotating between crops will improve crop growth and competitiveness. Related vegetables should not be grown in the same location in successive years (see Table 22).

Table 22: Botanically Related Vegetables

Alliums	Corn	Cucurbits	Crucifers	Goosefoot Family	Legumes	Nightshade Family
Chive	Dent corn	Cantaloupe	Cabbage	Beet	Dry bean	Eggplant
Garlic	Sweet corn	Cucumber	Cauliflower	Chard	Lima bean	Pepper
Leek		Pumpkin	Broccoli	Spinach	Pea	Potato
Onion		Summer squash	Brussels sprout		Snap bean	Tomato
		Watermelon	Horseradish		Soybean	
		Winter squash	Kale			
			Radish			
			Rutabaga			

Wild proso millet is an example of a problem weed where rotation is important for management. Rotation from sweet corn to small grains, early-planted peas, or alfalfa almost completely eliminates wild proso millet because these crops are established before the soil is warm enough for wild proso millet seed germination. A rotation from sweet corn to broadleaf crops would allow the use of postemergence grass herbicides to manage wild proso millet.

Once a crop is selected, use adaptive, vigorous varieties resistant to diseases. Disease-infected plants cannot effectively compete with weeds. Varieties suited for cultivation in regions covered by this publication are listed in each crop section of this guide.

Narrower row spacings and proper plant densities assure crop canopy closure. Closed canopies shade out later emerging weeds and prevent germination of weed seeds that require light. Weeds seldom are a problem after canopy closure. Proper row spacing and plant density also allow row cultivation.

Correct planting time is another cultural method that can improve crop competitiveness. Crops can be divided into warm- or cool-season plants, depending on the optimum temperature for their growth. Planting date affects the time until emergence and the crop's early seedling vigor, both of which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures, so compete better against early emerging weeds than warm-season crops. Table 23 lists crops according to their adaptation to field temperatures. Time plantings so temperatures are favorable for crop growth. Adequate fertilization and appropriate insect and disease management are important in assuring competitive crops. Adequate fertility assures rapid, uniform stand establishment and good crop growth, which enhance the crop's competitiveness. Disease management information and insect management information are contained in this guide. While poor insect and disease control reduce a crop's competitiveness, inadequate weed control also can cause insect and disease problems.

Mulching can be useful in managing weeds. Mulches can be classified as either natural (e.g., straw, leaves, paper, and compost) or synthetic (plastics). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1 to 1.5 inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough so they will not be easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil and do not need to be disposed of at the end of the season.

Synthetic mulches are easy to apply, control weeds within the row, conserve moisture, and increase soil temperature. Black or clear plastic mulches are the most common and are effective in improving early-season growth of warm-season crops such as tomato, cantaloupe, watermelon, or pepper. Fast early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation can also improve water use efficiency.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem, and they degrade into small pieces of plastic that contaminate the environment. Biodegradable plastic mulches are available.

Table 23: Classification of Vegetable Crops According to Their Adaptive Field Temperatures

Cool-season		Warm-season	
Hardy[1]	Semi-Hardy	Tender	Very Tender
Asparagus	Carrot	Snap bean	Cantaloupe
Broccoli	Cauliflower	Sweet corn	Cucumber
Cabbage	Chinese cabbage	Tomato	Eggplant
Horseradish	Lettuce		Lima bean
Onion	Potato		Okra
Pea			Pepper
Spinach			Pumpkin
			Squash
			Watermelon

[1]Hardy crops are most tolerant of cool temperatures and frost. Very tender crops are most susceptible to frost and cool temperatures.

Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as moldboard plows, disks, rotary hoes, and row cultivators. Mechanical weed management starts with seedbed preparation. Few no-till systems have been developed for vegetable crops. No-till suggestions are discussed in the sections on biological practices and reduced tillage systems.

Moldboard plowing is usually the first step in mechanically managing weeds. Moldboard plowing is particularly useful in controlling emerged annual weeds. Rotary hoeing is often an important second step in mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap bean, lima bean, and pea). Rotary hoeing should be done after the weeds germinate but before they emerge. Rotary hoeing does not control large-seeded weeds such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a row cultivator can be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. Best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which will reduce crop yields.

In some vegetable crops, such as asparagus, mowing can be an effective weed management tool. Mowing can prevent weed seed production and kill upright weeds, reducing competition. Mowing must be carefully timed to eliminate perennial, biennial, or annual weeds that would compete strongly in vegetables because of their upright growth habits. Timely, repeated mowing also helps deplete the food reserves (root systems) of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed management systems. Because mechanical management relies on relatively dry soil, a rainy period may prevent the use of mechanical weed management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is labor intensive, and many growers will use herbicides combined with nonchemical approaches to control especially difficult weeds. Some of these difficult-to-control weeds include wild proso millet in sweet corn, Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These are best controlled or eradicated with herbicides before large areas are infested.

Biological Practices

Currently, no management system tools exist in the Midwest for using insects or diseases to control weeds common in vegetable crops. Most biological weed management systems to date have been developed to control problem weeds in rangeland areas in the West. One biological system that has potential in the Midwest is the use of cover crops to suppress weed development. These systems are still experimental, but have promise for reducing herbicide use once they are fully developed.

The most promising cover crop system is winter rye. Winter rye is planted in late summer or early fall and overwinters as a cover crop. In the spring, the rye is killed two weeks prior to planting the desired crop. Rye can be killed using herbicides, or, once it has reached the reproductive stage, by mowing, or rolling and crimping. The rye is left as a mulch on the soil surface, and the crop is no-till planted. The system appears to provide early season control of many annual weeds. To obtain acceptable weed control, additional herbicides and/or mechanical control are usually required. The system should be evaluated in small areas before it is adopted.

Table 24 summarizes some nonchemical weed management practices (see page 59) The most effective weed management system is an integrated approach that combines many different practices. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

Chemical Weed Management Strategies

Several herbicides are often labeled for a particular crop. Scouting your area to determine which weeds are present will allow you to select the herbicides that will give you the best control.

All the herbicides labeled for a crop are not necessarily listed in this guide. If you are unfamiliar with an herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

Herbicide Labels

Always Read and Understand the Herbicide Label Before Use. Reading the herbicide label is a very profitable use of your time. Information on the label will direct you to the correct uses, application methods, rates, and potential environmental hazards of the product. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that affect crop injury, influence the effectiveness of weed control, and can cause nontarget site effects.

Do Not Use Any Herbicide Unless the Label States That It Is Cleared for Your Particular Use and Crop. Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted-use or general-use pesticide. Restricted-use pesticide labels contain a statement that the products are restricted and that only licensed applicators can buy them and supervise their application. The information in this production guide is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (EPA) registration of herbicides in the *Illinois Fruit and Vegetable News* (www.ipm.uiuc.edu/ifvn), the *Pest Management and Crop Development Bulletin* (www.ipm.uiuc.edu/bulletin/index.php), or the *Indiana Vegetable Crops Hotline* (vegcropshotline.org).

Reduced Tillage Systems

Reduced tillage systems combat soil erosion. These systems often include the use of glyphosate or paraquat outside the normal growing season to control emerged weeds. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying glyphosate to control perennial weeds, apply it before the soil is disturbed. After it is applied, glyphosate must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow glyphosate label directions carefully for rates and timing of applications. If perennial weeds are not a major problem, you can eliminate early weed flushes by applying glyphosate or paraquat to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply glyphosate or paraquat to an emerged crop because severe crop injury or death will occur.

Glyphosate and paraquat will control most annual broadleaf and grass weeds. Neither herbicide has any soil residual activity, so other weed control measures will be necessary during the growing season. Paraquat will suppress perennials by killing their shoots, but it does not control regrowth of perennial weeds from rhizomes or other underground storage organs. Glyphosate is better for controlling perennials because it will kill shoots and translocate to destroy underground parts. Glyphosate will only suppress some particularly hard-to-control perennials such as bindweed, hemp dogbane, and milkweed. To control these perennials, high application rates, repeat applications of glyphosate (within label guidelines), or mechanical removal may be necessary.

Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in this guide are in amount of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Several materials may be used between crop rows if appropriate steps are taken to prevent spray from contacting the crop. Some of these materials require shielded sprayers, while others require hooded sprayers. The herbicide recommendations in this guide do not replace careful reading of current herbicide labels. Re-registration of older herbicides has affected the availability of many products. Some of the older herbicides not re-registered are not listed in this bulletin, but may be available, and old stocks can still be used.

Environmental and Health Hazards of Herbicides

Herbicides can have nontargeted effects, so it is very important that you educate yourself about these effects and consider them when designing weed management systems. The following section contains discussions of some of the potential environmental and health hazards of herbicides.

Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct, and must be avoided. Some environmental hazards, such as herbicide drift and carryover, will mainly affect your operation, while other hazards, such as water contamination, affect all residents in the area. The following sections discuss some of the potential hazards and methods to avoid them.

Herbicide carryover. Herbicide carryover from persistent herbicides has been a particular problem to vegetable crop growers. Persistence depends on herbicide characteristics (method of degradation, water solubility, and rate of application) and site characteristics (soil type, rainfall, and temperature). Avoid carryover because correcting carryover problems after they have occurred is virtually impossible. The most important method to avoid herbicide carryover is to follow label rotation restrictions. Table 25 summarizes some of the label restrictions (see page 60) Always refer to the label for specific information. If there are differences between the table and herbicide label, always follow label information.

Herbicide drift. Another frequent hazard to vegetable growers is crop injury from herbicide drift. Certain herbicides, if not used correctly, can injure nontarget plants. Herbicides such as clomazone (Command®), dicamba, and 2,4-D can drift up to a mile and seriously damage grapes, tomatoes, peppers, other vegetables, fruit trees, and ornamental plants. Before spraying clomazone, dicamba, or 2,4-D, survey the area for desirable plants.

Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use an amine formulation of 2,4-D to reduce vapor drift. Spray clomazone, dicamba, and 2,4-D when the temperature is expected to be lower than 80°F to 85°F for several days after treatment. Avoid applying clomazone to wet soils.

Spray tank residuals. Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Herbicide resistance. More than 180 weed species have developed resistance to one or more herbicides. Herbicide-resistant populations tend to develop when herbicides with the same mode of action for killing weeds are used every year in the same field. The Herbicide Resistance Action Committee (HRAC) groups herbicides according to their modes of action. Table 28 lists the HRAC groups for vegetable herbicides.

Weeds resistant to herbicides in HRAC Group B (ALS inhibitors) make up 30 percent of the documented resistant biotypes. Sandea®, Permit®, Matrix®, Raptor®, and Pursuit® are vegetable herbicides in this group. Weeds resistant to herbicides in HRAC Group C1 (Photosystem II inhibitors) make up another 20 percent of the documented resistant biotypes. Atrazine, Sencor®, and Sinbar® are in this group. Widespread glyphosate use in agronomic crops has led to the development of glyphosate-resistant weeds, although they still only represent 3.5 percent of resistant biotypes.

Approaches that aim to prevent herbicide resistance combine the use of herbicides, mechanical (cultivation), and cultural (crop rotation) weed management practices. It is important to avoid relying on herbicides from a single HRAC group year after year. Rotate between, or use tank mixes of, herbicides with different modes of action. For example, in asparagus rotate between Sencor® and Treflan®. Use tillage to control weeds that escape from herbicide applications. To minimize any weed resistance that does occur, it is especially important to scout your fields, paying special attention to any patches of a weed normally controlled by the herbicide. Herbicide labels may contain additional information about avoiding resistance problems.

Water quality. Residues of some herbicides such as atrazine, metolachlor, and metribuzin have been found in surface and ground water. Detected levels have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is a particular concern in areas of the Midwest with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are a particular concern.

Site characteristics (soil type, soil depth, water table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contamination of surface and subsurface water resources.

Table 24: Summary of Nonchemical Weed Management Practices

Cultural	
Land selection	Avoid fields with a history of weed problems.
Crop selection	Grow the most competitive crops in fields with histories of weed problems.
Crop rotation	Rotate between vegetables and non-row crops such as alfalfa. Rotate between vegetables in different botanical categories.
Adapted crop varieties	Select crop varieties adapted for your area.
Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop canopy closure.
Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence. Do not plant warm-season crops too early in the season.
Appropriate crop management	Vigorous, healthy crops are more competitive against weeds and insects.
Mulch	Natural mulches may be appropriate on small acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
Mechanical and Thermal	
Moldboard plowing	This can eliminate emerged annual weeds.
Rotary hoeing	This is useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap bean, lima bean, and pea.
Row cultivator	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Flame weeding	Flame weeding, or using a hot flame to kill weeds, is effective for stale seedbed weed removal or weeds that emerge before the vegetable crop. Flame weeding is effective for weed control in vegetables such as onions, parsnips, and carrots. Some growers have successfully used flame weeding on transplanted onions that are 8-10 in. tall. Sweet corn that has just emerged and potatoes up to 2 in. tall can be flame weeded.
Biological	
Cover crops	This is still experimental. Winter rye system is the most promising and most effective against small-seeded broadleaf weeds.
Insect or disease pests or weeds	No current systems use insects or diseases to manage weeds in common vegetables.

The lesions on this sweet corn leaf were caused by drift from a contact herbicide. Reduce the possibility of herbicide drift by paying attention to weather conditions and using nozzles that apply the products in large drops.

Table 25: Label Restrictions (in Months) on Rotating to Vegetable Crops

Herbicide	Tomato	Pea	Snap Bean	Sweet Corn	Pumpkin	Melon	Cole Crops
Soybean Herbicides							
Authority Assist®	40	10	10	18	40	40	18-40V
Authority First®, Sonic®	30+FB	12-30+FB,V	30+FB	18	30+FB	30+FB	30+FB
Boundary®	12	8	12	12	12	12	12
Canopy®, Canopy EX®	9-10[1]	9-12	9-12	18	18	18-30	18-30V
Classic®	15[1]	FB	FB	FB	FB	FB	FB
Command®	9	AT	9	9	AT	9	V
Domain®	NNY	NNY	NNY	NNY	NNY	NNY	NNY
Envive®	12[1]	12	12	18	18	18-30V	18-30V
Extreme®	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V
First Rate®	30	9	9	18	30	30	30
Flex Star®	18	10	10	18	18	18	18
Gauntlet®	NNY	NNY	NNY	18	NNY	NNY	NNY
Optill®	40+FB	4	4	18	40+FB	40+FB	40+FB
Prefix®	18	18	0	10	18	18	18
Pursuit DG®[2]	40+FB	4	4	18	40+FB	40+FB	40+FB
Python®	26	4	4	10.5-18V	26	26	26
Raptor®	9	AT	AT	9	9	9	V
Reflex®	18	10	18	10	18	18	18
Sencor®	4	8	12	12	12	12	12
Scepter®	18	18	11	18	18	18	18
Spartan®	12	12	12	18	12	12	12V
Synchrony STS®	9[1]	15	15	15	15	15	15
Valor®	12+FB	12+FB	12+FB	4	12+FB	12+FB	12+FB
Valor XLT®	12	12	12	18	18	18	18
Corn Herbicides							
Aatrex® and others	NNY	NNY	NNY	AT	NNY	NNY	NNY
Accent®, soil pH < 6.5	10	10	10	10	10	10	10
Accent®, soil pH > 6.5	18	18	18	18	18	18	18
Anthem®, Anthem ATZ®	18	18	18	AT	18	18	18
Aim®	AT	AT	AT	AT	V	V	12
Balance Pro®	18V	18V	18V	6	18V	18V	18V
Basis®	18	8	8	10	18	18	18
Beacon®	18	18	18	8	18	18	18
Bicep®, Bicep II®	18	18	18	AT	18	18	18
Callisto®	18	18	18	AT	18	18	18
Camix®	18	18	18	AT	18	18	18
Celebrity®, Celebrity Plus®	10-18V	10	10	10-15V	10-18V	18-18V	18-18V
Corvus®	17-24V	17-24V	17-24V	9-17V	17-24V	17-24V	17-24V
Define®	12	12	12	AT	12	12	4-12V
Hornet®	26	10.5-18V	10.5-18V	10.5-18V	26	26	26
Harness Xtra®	NNY	NNY	NNY	NY	NNY	NNY	NNY
Impact®	18	9	9-18V	AT	18	18	18
Lariat®, Bullet®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Laudis®	10	10	10	AT	18	18	18
Leadoff®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Lightning®	40	9.5	9.5	18	40	40	40
Lumax®, Lexar®	18	18	18	AT	18	18	18
Marksman®	18	18	18	AT	18	18	18
Northstar®	18	8	18	8	18	18	18
Permit®	8[1]	9	9	3	9	18	15-18
Prequel®	18	18	10-18V	10	18	18	18
Princep®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Resolve DF®, ResolveQ®	1-1.5	10	10	10	18	18	18
Spirit®	10-18V	10V	10V	8V	18	18	18
Steadfast®	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Stinger®	18	18	18	AT	18	18	AT
Surestart®	26+FB	NY	26+FB	10.5-18V	26+FB	40+FB	26+FB
Surpass®, TopNotch® Ful-Time®	NNY	NNY	NNY	NY	NNY	NNY	NNY

1Transplanted tomatoes only.
[2]In Indiana, the replant restriction for transplanted tomatoes and peppers, cabbage, melons, and cucumbers is 18 months. AT=anytime herbicide labeled for the crop or no rotation restriction exists, FB= field bioassay required before planting the crop, NY=the crop can be planted the year after application, NNY= not next year, the crop cannot be planted the following year, V=variable, intervals vary by crop variety or other conditions specified on label.

Table 26: Relative Effectiveness of Herbicides for Vegetable Crops[1]

Ratings Key G=Good F=Fair P=Poor N=None/None Labeled		Barnyardgrass	Crabgrass	Fall Panicum	Foxtails	Goosegrass	Yellow Nutsedge	Morningglory, Annual	Galinsoga	Jimsonweed	Lambsquarters	Nightshade	Pigweed	Purslane	Common Ragweed	Smartweed	Velvetleaf
Preplant Incorporated Herbicides	Balan®	G	G	G	G	G	P	P	P	P	F	P	G	P	P	P	P
	Devrinol®	G	G	G	G	G	N	N	P	N	F	N	G	G	N	P	N
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Eptam®	G	G	G	G	G	F	P	P	N	F	F-P	G	G	P	P	F
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P
	Prefar®	G	G	G	G	G	N	N	N	N	F	N	F	F	N	N	N
	Ro-Neet®	G	G	G	G	G	F	N	F	N	F	P	G	F	P	P	P
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Sonalan®	G	G	G	G	G	N	N	N	N	F-G	F	F-G	F-G	N	P	N
	trifluralin	G	G	G	G	G	N	F	N	N	G	P	G	G	P	P	P
Preemergent Surface Applied Herbicides	acetochlor	G	G	G	G	G	G	P	G	P	G	G	G	F	F	P	P
	acetochlor+atrazine	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	F
	alachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Anthem®	G	G	G	G	G	P	F	N	F	F	G	G	G	F	P	F
	Anthem ATZ®	G	G	G	G	G	F	F	G	G	G	G	G	G	G	G	F
	atrazine	G	G	P	F	G	F	F-G	G	G	G	G	G	G	G	G	F
	Callisto®	N	N-P	N	N	N	N	F	G	G	G	G	G	N	P	G	G
	Camix®	G	G	G	G	G	G	F	G	G	G	G	G	G	F	G	G
	Chateau®	F	F	F	F	F	N	G	N	G	G	G	G	G	G	G	G
	Command®	G	G	G	G	G	N	F	P	F	G	P	P	G	G	G	G
	Curbit®	G	G	G	G	G	N	N	F	N	F	F	G	G	P	P	N
	Dacthal®	G	G	G	G	G	N	N	P	P	F	N	F	F	N	N	N
	Define®	G	G	G	G	G	F	N	N	N	F	F	F	G	F	N	N
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	halosulfuron	P	P	P	P	P	G	N	G	P	G	P	G	F	G	G	G
	Karmex®	G	F	F	G	G	P	G	G	G	G	G	G	G	G	G	G
	Kerb®[2]	F	F	P	F	F	P	P	P	P	F	P	P	G	F	F	P
	League®	F	F	N	F	N	G	N	G	N	G	F	G	G	G	N	N
	Lexar®	G	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G
	linuron	F	F	F	F	F	N	P	G	F	G	F	G	G	G	G	G
	Lumax®	G	G	G	G	G	G	F	G	G	G	G	G	G	F	G	G
	Matrix®	G	P-F	G	G	G	P	P	N	F	F	P	G	F	P-F	F	F
	metribuzin	F	F	F	F-G	F	N	N	G	F	G	N	G	G	G	G	G
	oxyfluorfen	P	F	F	P	P	N	F	G	F-G	G	G	G	G	G	G	F
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P
	Pursuit®	P	P	P	G	P	P	P	G	F	F	G	G	G	P	G	F
	Sinbar®	G	G	G	F-G	G	P	F-G	G	G	G	G	F-G	G	G	G	G
	Sharpen®	N	N	N	N	N	N	P-F	G	F-G	G	G	G	F-G	G	G	G
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Solicam®	G	G	G	G	G	F	N	G	N	F	F	F	F	G	F	F
	Spartan®	F	F	F	F	F	G	G	G	G	G	F	G	G	N	G	F
	Strategy®	G	G	G	G	G	N	F	P	F	G	P	F	F	F	F	G
	Zidua®	G	G	G	G	G	F	P	G	P	F	G	G	G	P	P	N
Postemergent Herbicides	2,4-D	N	N	N	N	N	N	G	G	F	G	G	G	P	G	P	F
	Aim®	N	N	N	N	N	N	G	N	N	G	G	F-G	N	F	F	G
	Anthem®	P	P	P	P	P	P	G	N	G	G	F	F	N	P	F	G
	atrazine + oil	G	G	F	F-G	G	G	F-G	G	G	G	G	G	G	G	G	G
	bentazon	N	N	N	N	N	G	F	G	G	F	P	P	F-G	F	G	G
	bromoxynil	N	N	N	N	N	N	G	N	G	G	G	F	P	G	G	G
	Cadet®	N	N	N	N	N	N	N	N	F	F	F	F	N	N	N	G
	Callisto®	N	N-P	N	N	N	N	F	G	G	G	G	G	N	F	G	G
	clethodim	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	clopyralid	N	N	N	N	N	N	N	G	G	P	F	P	N	G	F	N
	dicamba	N	N	N	N	N	N	G	G	F	G	G	G	G	G	G	G
	Evik®[3]	G	G	G	G	G	F	G	G	G	G	F	G	F	G	G	G
	fomesafen	N	N	N	N	N	N	N	N	N	N	F-G	N	N	F-G	N	N
	Fusilade®	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	glyphosate	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	G
	halosulfuron	N	N	N	N	N	G	F	G	N	P	N	F-G	N	G	F-G	G
	Impact®	F	F	P	P-F	F	N	P	G	G	G	G	G	N	G	G	G
	Laudis®	G	G-F	F	F-G	G	N	F	G	P	G	G	G	N	G	G	G
	League®	F	F	N	N	N	G	G	G	N	N	N	G	G	N	F	N
	linuron	F	F	F	F	F	N	G	G	F	G	G	G	G	G	G	G
	Matrix®	G	P-F	G	G	G	F	F	N	N	F	P	G	F	P-F	F	F
	metribuzin	F	F	F	F	F	N	F-G	G	F	G	P	G	G	G	G	G
	nicosulfuron	G	P	G	G	G	P	G	P	G	P-F	P	G	P	P	G	P
	Option®	G	F	G	G	G	P	F	P	G	G	G	G	G	G	F	G
	oxyfluorfen	P	P	P	P	P	N	F	G	G	F	G	F	G	G	F	F
	paraquat	G	G	G	G	G	G	G	F-G	G	G	G	G	G	G	G	G
	Poast®	G	F-G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	quizalofop	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	Raptor®	G	G	N	G	N	P-F	P-F	N	G	F	G	G	F	P-F	G	G
	Spin-aid®	N	N	N	N	N	N	F	G	F	G	F	P	G	G	G	F
	Starane®	N	N	N	N	N	N	G	N	F	P	F	P	G	G	P	G
	Thistrol®	N	N	N	N	N	N	F	N	N	F	N	F	N	N	F	N

[1] For pre-packaged mixtures, see ratings for individual components.
[2] Excellent against quackgrass.
[3] Post-directed spray.

Table 27: Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2015[1]

	2,4-D	acetochlor	acetochlor+atrazine	Aim®	alachlor	Anthem®, Anthem ATZ®	Assure II®/Targa®	atrazine	atrazine+dimethenamid-P	atrazine+s-metolachlor	Balan®	bentazon	bromoxynil	Cadet®	Callisto®	Casoron®	Chateau®	clethodim	clopyralid	Command 3ME®	Curbit®	Dacthal®	Devrinol®	dicamba	dimethenamid-P	diuron	Eptam®	Expert®	fomesafen	Fusilade®	glyphosate	Goal®, Galigan®
Asparagus	X														X		X	*1*					X	1		X				1	X	
Beet				X														30	30												X	
Broccoli				X														30		X		X									X	X
Cabbage				X														30		45		X									X	X
Cantaloupe				X														14		X	X	X									X	
Carrot				X														30												45	X	
Cauliflower				X														30				X									X	X
Collard				X														14				X									X	
Cucumber				X														14		45	X										X	
Dry Bean				X			30											30							70		X		45	60	X	
Eggplant				X														20				X	X								X	
Endive/Escarole				X														*14*													X	
Garlic				X									112				X	45							30					45	X	60
Horseradish				X														30				X			40						X	
Kale				X														14				X									X	
Leek				X														*14*				X									X	
Lettuce				X							X							X													X	
Lima Bean				X								30						*30*													X	
Mint		*40*					30					X	70				80	21	45	84											X	X
Mustard				X														14				X									X	
Okra				X																											X	
Onion, dry bulb				X									X				45	45				X			30					45	X	45
Onion, green bunching				X									X					*14*				X			30						X	
Parsley				X														*14*													X	
Parsnip																		30													X	
Pea				X			30					30						*21*													X	
Pepper				X														20		X			X								X	
Potato				X														30							40		45		*70*		X	
Pumpkin				X														14			X										X	
Radish				X														15													X	
Rhubarb				X											X	X		30		X											X	
Snap Bean				X			15					30						*21*		45							X		30		X	
Spinach				X														14	21												X	
Squash				X														14		45	X										X	
Sweet Corn	X	X	X	X	X	X		X	50	X		X		*40*	45				30						50			*X*			X	
Sweet Potato				X														30		95		X								55	X	
Tomato				X														20				X	X								X	
Turnip, greens				X														14	15			X									X	
Turnip, root				X														30	30			X									X	
Watermelon				X														14		X	X	X									X	
Re-Entry Intervals (hours)	48	12	12	12	12	12	12	12	12	24	12	12	24	12	12	12	12	12	12	12	24	12	12	24	12	12	12	24	24	12	12	24

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Table 27 (continued)

	halosulfuron	Impact®	Kerb®	Laudis®	League®	linuron	Matrix®	metribuzin	nicosulfuron	Optill®	Option®	paraquat	Poast®	Prefar®	Priority®	Prowl H2O®	Pursuit®, Thunder®	Pyramin®	Raptor®	Ro-Neet®	Sandea® or Profine 75®	Sharpen®	Sinbar®	s-metolachlor	Solicam®	Sonalan®	Spartan®	Spartan Advance®	Spartan Charge®	Spin-Aid®	Starane®, Starane Ultra®	Strategy®	Thistrol®	trifluralin	Valor®	Zidua®
Asparagus						1		14				6	1								1		5		14									X		
Beet													60					X		X				X						60						
Broccoli													30	X																			X		
Cabbage												X	30	X													X		X				X			
Cantaloupe					48							X	14	X		35					57			X								X				
Carrot						14		60					30			X								64										X		
Cauliflower													30	X																			X		
Collard													30	X										X									X		
Cucumber													14	X							30			X								45				
Dry Bean												X	30			X	60		X		30			X		X								X		
Eggplant												X	20	X							30													X		
Endive/Escarole			56										15	X																				X		
Garlic												X	30	X		45								X												
Horseradish													60														X		X							
Kale													30	X										X										X		
Leek													30			30																				
Lettuce			55									X	15-30	X																						
Lima Bean													15			X			X		30			X										X		
Mint													20			X							60				X						40	X		
Mustard													30	X										30										X		
Okra													14								30			60									X			
Onion, dry bulb												60	30	X		45								60										60		
Onion, green bunching													30			30								21												
Parsley						30							15	X																						
Parsnip						X							14																							
Pea										X			15			X	X		X			X		X			X	X	X					X		
Pepper					21							X	20	X		X					30			X										X		
Potato					45	X	60	60					30			X								40-60										X		
Pumpkin												X	14	X							30			30								X				
Radish													14											X										X		
Rhubarb													30																							
Snap Bean													15			X			X		30			X										X		
Spinach													15											50												
Squash												X	14	X							30			30								45				
Sweet Corn	30	45		X					X		45	X	30		30	X					30			X							31					37
Sweet Potato																																		X		
Tomato					21		45	7				30	20			X					30			90			X							X		
Turnip, greens													14											30												
Turnip, root													14											X												
Watermelon					48							X	20	X		35					57		70	60								X				
Re-Entry Intervals (hours)	12	12	24	12	12	24	4	12	4	12	12	12-24	12	12	12	24	12	12	4	12	12	12	12	24	12	24	12	12	12	24	12	24	24	12	12	12

X=check label for details.

[1]Check label directions before applying any of these pesticides.

Table 28: Common Names of Registered Herbicides[1]

Common Name	Trade Name	Producer	WSSA Group	HRAC Group2	Formulation
2,4-D Amine	Amine 40®, others	PBI Gordon, others	4	O	4L, 75WSG
acetochlor	Surpass®, TopNotch®	Dow AgroSciences	15	K3	6.4EC, 3.2ME
	Breakfree®	DuPont	15	K3	6.4EC
	Confidence®, Degree®, Harness®	Monsanto	15	K3	7EC, 3.8 EC, 7EC
acetochlor+ atrazine	FulTime®, Keystone®, Keystone LA®	Dow AgroSciences	15, 5	K3, C1	2.4+1.6ME, 3+2.25 SC, 4+1.5 SC
	Breakfree ATZ®, Breakfree ATZ Lite®	DuPont	15, 5	K3, C1	3.0+2.25 EC, 4+1.5 EC
	Harness XTRA®, HARNESS XTRA 5.6L®	Monsanto	15, 5	K3, C1	4.3+1.7 EC, 3.1+2.5 EC
alachlor	Lasso®, Micro-tech®	Monsanto	15	K3	4L, 4ME
ametryn	Evik®	Syngenta	5	C1	76DF
atrazine	many	many	5	C1	90DF, 4L
atrazine+ dimethenamid-P	Guardsman Max®, G-Max Lite®	BASF	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Commit ATZ®, Commit ATZ Lite®	Winfield Solutions	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Establish ATZ®, Establish Lite®	Tenkoz	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Propel ATZ®, Propel ATZ Lite®	Rosen's	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Slider ATZ®, Slider ATZ Lite®	Loveland Products	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Sortie ATZ®, Sortie ATZ Lite®	Helena	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
	Watchman®, Watchman Lite®	United Suppliers	5, 15	C1, K3	3.3+1.75EC, 2.75+2.25EC
atrazine+s-metolachlor	Bicep II Magnum®, Bicep II Magnum FC®, Bicep Lite II®, Magnum®, Medal II AT®	Syngenta	5, 15	C1, K3	3.1+2.4SC, 2.67+3.33SC
	Brawl II ATZ®	Tenkoz	5, 15	C1, K3	3.1+2.4SC, 2.67+3.33SC
	Charger Max®, Charger Max Lite®	Winfield Solutions	5, 15	C1, K3	3.1+2.4SC, 2.67+3.33SC
	Cinch ATZ®, Cinch ATZ Lite®	DuPont	5, 15	C1, K3	3.1+2.4SC, 2.67+3.33SC
atrazine+ s-metolachlor + glyphosate	Expert®	Syngenta	27, 5	F2, C1, G	2.14+1.74+1.0EC
benefin	Balan®	United Agri-Products	3	K1	60DF
bensulide	Prefar®	Gowan	8	N	4E
bentazon	Basagran®	Arysta	6	C3	4L
bromoxynil	Buctril®	Bayer CropScience	6	C3	2EC, 4EC
	Moxy 2E®	Winfield Solutions	6	C3	2SC
carfentrazone	Aim®	FMC	14	E	40DF
carfentrazone+ halosulfuron	Priority®	Tenkoz	14, 2	E, B	12.5+50WDG
carfentrazone+ sulfentrazone	Spartan Charge®	FMC	14	E,	0.35+3.15EC
clethodim	Arrow 2EC®	Makhteshim Agan	1	A	2EC
	Cleo 26.4®	Ritter Chemical	1	A	2EC
	Clethodim 2E®	Albaugh	1	A	2EC
	Clethodim 2EC®	AmTide	1	A	2EC
	Intensity®, Intensity One®	Loveland Products	1	A	2EC, 0.97EC
	Section 2EC®	Winfield Solutions	1	A	2EC
	Select®, Select Max®	Valent	1	A	2EC, 0.97EC
	Shadow®	Arysta LifeScience	1	A	2EC
	Tapout®	Helena Chemical	1	A	0.97EC
	Volunteer®	Tenkoz	1	A	2EC
clomazone	Command®	FMC	13	F3	3ME
clomazone+ ethalfluralin	Strategy®	UAP/Platte	13, 3	F3, K1	0.5+1.6 EC
clopyralid	Stinger®	Dow AgroSciences	4	O	3E
	Clopyr®	United Phosphorus	4	O	3E
cycloate	Ro-Neet®	Helm Agro	8	N	6E
DCPA	Dacthal®	AMVAC	3	K1	75W, 6F

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Table 28: Common Names of Registered Herbicides[1] (continued)

Common Name	Trade Name	Producer	WSSA Group	HRAC Group2	Formulation
dicamba	Clarity®	BASF	4	O	4L
	Banvel®	Arysta LifeScience	4	O	4L
	Detonate®	Tenkoz	4	O	4L
	Dicamba DMA®, Dicamba HD®	Albaugh	4	O	4L
	Rifle®, Strut®	Loveland Products	4	O	4L
	Sterling®	Winfield Solutions	4	O	4L
	Vision®	Helena Chemical	4	O	3.8EC
dichlobenil	Casoron®	Chemtura	20	L	4G
dimethenamid-P	Outlook®	BASF	15	K3	6E
	Establish®	Tenkoz	15	K3	6E
	Propel®	Rosen's	15	K3	6E
	Slider®	Loveland Products	15	K3	6E
	Sortie®	Helena	15	K3	6E
diquat	Reglone®	Syngenta	22	D	2E
	Diquat E AG 2L®	Nufarm Agricultural Products	22	D	2E
	Rowrunner AG®	Rotam North America	22	D	2E
diuron	Karmex®	DuPont, Griffin	7	C2	80DF, 4F
	Direx®	Griffin	7	C2	80DF, 4L
	Diuron®	Drexel, Loveland Products, Makhteshim Agan, Winfield Solutions	7	C2	80DF, 4L
EPTC	Eptam®	Gowan	8	N	7E
ethalfluralin	Curbit®	United Agri-Products	3	K1	3EC
	Sonalan®	Dow AgroSciences	3	K1	3EC
fluazifop-butyl	Fusilade DX®	Syngenta	1	A	2E
flufenacet	Define DF®, Define SC®	Bayer CropScience	15	K3	60DF, 4F
flumioxazin	Chateau WDG®, Chateau SW®, Valor SX®	Valent	14	E	51WDG
	Encompass®	Tenkoz	14	E	
fluroxypyr	Starane®, Starane Ultra®	Dow AgroSciences	4	0	1.5EC, 2.8L
fluthiacet-methyl	Cadet®	FMC	14	E	0.91L
fomesafen	Reflex®	Syngenta	14	E	2L
	Battlestar®	Albaugh	14	E	2SC
	Dawn®	Cheminova	14	E	2L
	Fomesafen 2®	Solera Ato	14	E	2EC
	Top Gun®	Loveland	14	E	2EC
	Willowood Fomesafen®	Willowood	14	E	1.88EC
fomesafen+ imazethapyr	Camo Multipack®	Albaugh	14, 2	E, B	SC
foramsulfuron	Option®	Bayer CropScience	2	B	35WDG
glufosinate	Rely 200®	Bayer CropScience	10	H	1.67L
glyphosate	many	many	9	G	many
halosulfuron	Permit®	Gowan	2	B	75WSG
	Halomax 75®	Aceto Agricultural Chemicals	2	B	75WSG
	Profine 75®	Aceto Agricultural Chemicals	2	B	75WSG
	Sandea®	Gowan	2	B	75WSG
imazamox	Raptor®	BASF	2	B	1EC
imazethapyr	Pursuit®	BASF	2	B	70DG
	Thunder®	Albaugh	2	B	2SC
imazosulfuron	League®	Valent	2	B	75WDG
linuron	Lorox®, Linex®	Griffin	7	C2	50DF, 4L
MCPB	Thistrol®	Nufarm	4	O	2L
mesotrione	Callisto®	Syngenta	27	F2	4L
mesotrione+ atrazine	Callisto Xtra®	Syngenta	27, 5	F2	0.5+3.2EC
mesotrione+ s-metolachlor	Camix®	Syngenta	27, 15	F2, K3	0.33+3.34EC
mesotrione+ s-metolachlor+ atrazine	Lumax®, Lexar®	Syngenta	27, 15, 5	F2, K3, C1	0.268+ 2.68+1EC; 0.224+1.74+1.74EC

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Table 28: Common Names of Registered Herbicides[1] (continued)

Common Name	Trade Name	Producer	WSSA Group	HRAC Group2	Formulation
s-metolachlor	Dual (II) Magnum®, Medal®, Medal II®	Syngenta	15	K3	7.6E
	Brawl®, Brawl II®	Tenkoz	15	K3	7.6EC
	Cinch®	DuPont	15	K3	7.6EC
	Charger Basic®	Winfield Solutions	15	K3	7.6SC
metribuzin	Sencor®	Bayer Cropscience	5	C1	4F, 75DF
	Dimetric®	Winfield Solutions	5	C1	75DF
	Metri®, TriCor®	United Phosphorus	5	C1	4F, 75DF
	Metribuzin 75®	Loveland Products	5	C1	75DF
	Metribuzin 75DF®	Makhteshim Agan	5	C1	75DF
napropamide	Devrinol®	United Phosphorus	15	K3	50DF, 2E
			15	K3	
nicosulfuron	Accent Q®, Accent®	DuPont	2	B	54.5WDG, 75DF
	Adapt®	Makhteshim Agan	2	B	75DF
	Primero®	Rotam North America	2	B	75DF
norflurazon	Solicam®	Syngenta	12	F1	80DF
oxyfluorfen	Goal®, GoalTender®	Dow AgroSciences	14	E	2E
	Galigan®, Galigan®, H2O®	Makhteshim Agan	14	E	2E, 4E
oxyfluorfen+ glyphosate	Galigan®, Slapshot®	Makhteshim Agan	14, 9	E, G	2+1.33 EC
paraquat	Gramoxone Inteon®	Syngenta	22	D	2L
	Firestorm®	Chemtura	22	D	3L
	Paraquat Concentrate®	Solera Source Dynamics	22	D	3L
	Parazone®	Makteshim Agan	22	D	3L
pelargonic acid	Scythe®	Dow AgroSciences	Not classified	Z	4.2L
pendimethalin	Prowl®	BASF	3	K1	3.3E, 3.8ACS
	Acumen®	Tenkoz	3	K1	3.3E
	Pendant®	Winfield Solutions	3	K1	3.3E
	Pendimax®	Dow AgroSciences	3	K1	3.3E
	Pendimethalin®	Helena Chemical	3	K1	3.3E
phenmedipham	Spin-Aid®	Bayer Cropscience	5	C1	1.3E
pronamide	Kerb®	Dow Agrosciences	3	K1	50W
pyrazon	Pyramin®	BASF	5	C1	65DF, 4.5SC
pyroxasulfone	Zidua®	BASF	15	K3	0.85WG
quizalofop	Assure II®	DuPont	1	A	0.88E
	Targa®	Gowan	1	A	0.88E
rimsulfuron	Matrix®	DuPont	2	B	25DF, 25WSG
	Pruvin®	Makteshim Agan	2	B	25DF
saflufenacil	Sharpen®	BASF	14	E	2.85SC
saflufenacil + imazethapyr	Optill®	BASF	14, 2	E, B	0.18+ 0.5WDG
sethoxydim	Poast®	BASF	1	A	1.5E
sulfentrazone	Spartan®	FMC	14	E	75DF
sulfentrazone + carfentrazone	Spartan Charge®	FMC	14, 14	E, E	3.15 + 0.35EC
sulfentrazone + glyphosate	Spartan Advance®	FMC	14, 9	E, G	0.56 + 4SC
tembotrione	Laudis®	Bayer CropScience	27	F2	3.5SC
terbacil	Sinbar®	DuPont	5	C1	80W
topramezone	Armezon®	BASF	27	F2	2.8EC
	Impact®	Amvac	27	F2	2.8EC
trifluralin	Treflan HFP®, Treflan TR-10®	Dow AgroSciences	3	K1	4E, 10G
	Treflan®	Helena Chemical, Loveland Products	3	K1	4E
	Trifluralin®	Albaugh, Gowan, Loveland Products, Tenkoz	3	K1	4E, 10G
	Triflurex HFP®	Makteshim Agan	3	K1	4E
	Trust®	Winfield Solutions	3	K1	4E, 10G

[1]See inside front cover for abbreviations.
[2]Herbicide Resistance Action Committee Groups: Herbicides in the same HRAC group have similar modes of action for killing weeds. To reduce the risk of herbicide resistance, do not rely on herbicides in a single HRAC group year after year.

Disease Management Strategies

Disease Diagnosis

Before making any management decisions, always make sure to get the right diagnosis of your problem first.

Accurate diagnoses can save time and money because some diseases look alike but have very different management strategies. Moreover, there are several plant health issues (nutritional problems, herbicide injuries, and others) that mimic plant diseases. Unwittingly treating a nutrient deficiency with pesticides wastes time and money, and does not solve the underlying condition.

Submitting samples to a diagnostic laboratory is the best way to ensure the correct diagnosis. For a list of labs, see pages 42-43.

Healthy Plant Material

Contaminated seed or transplants can introduce diseases, so saving vegetable seeds for next year's crop is not recommended. Table 29 (page 69) lists some diseases that may be transmitted by seed to transplants.

Whether you are purchasing transplants or producing them yourself (see Transplant Production, page 20). Be certain to inspect seedlings regularly.

Disease-resistant Varieties

Whenever possible, use varieties resistant to diseases. Some varieties may not be completely resistant to particular diseases, however, incomplete or partial resistance may be available. Some seed catalogs may refer to tolerance. Table 29 presents information about the availability of resistant varieties.

Tillage and Crop Rotation

In most situations, crop rotation and fall tillage are the most effective factors in disease management. This is because most pathogens overwinter in crop residues and are unable to survive once the residue decomposes. Tillage (especially fall tillage) helps control diseases by reducing the amount of inoculum (pathogen structures) that survives the winter.

Rotating fields to different crops each year also helps control diseases by preventing the build-up of certain plant pathogens in the soil. Table 29 provides tillage and crop rotation recommendations. A general rule states that crops should not be rotated to others in the same botanical family. Table 21 identifies botanically related crops.

There are three kinds of soilborne diseases that are unaffected by rotation.

The first group of these diseases is caused by pathogens that produce resilient survival structures that can withstand the effects of time and nonhost crops. Examples include Fusarium wilt, and root knot nematode.

The next group of these diseases has a broad host range, so they can survive indefinitely on many host crop and weed species. Examples include Sclerotinia, Rhizoctonia, and Verticillium diseases.

The third group of these diseases overwinters in Gulf Coast states, and then spread north by wind during the growing season. Examples include sweet corn rust and downy mildew of cucurbits.

Consider all options before making management decisions. Rotation is a good general practice that improves or maintains good soil tilth. Tillage (especially fall tillage) often is not in accord with recommended soil management and conservation practices.

Other Cultural Practices

Other practices, such as altering planting times, modifying irrigation methods or schedules, using raised beds, or altering plant density, also can make conditions less favorable for disease. Some of these practices are listed under comments in Table 29.

Chemical Control: Fungicides, Bactericides, Nematicides, Fumigants

Fungicides can be classified as either contact or systemic.

Contact fungicides, also called protectant fungicides, provide a "coat" of protection on the plant's surface when applied properly. These fungicides are designed to kill fungi on the surface of plants on contact — hence, the name.

Systemic fungicides, sometimes called eradicant or curative fungicides, don't merely coat the surface, they also enter into the plant. They can sometimes eradicate or cure a portion of existing infections.

Both contact and systemic fungicides are most effective if they are applied before disease develops. Some worry that using fungicides may lead to pathogens becoming resistant to the chemical. Most contact fungicides have multiple modes of action, so fungal pathogens are unlikely to develop resistance to all of these different modes of action at the same time. For this reason, alternating contact fungicides is unnecessary. Most

systemic fungicides have a single mode of action, so the risk of pathogens developing resistance to these products is greater. Always read and follow label directions that list how to alternate systemic fungicides and minimize the resistance development. Table 32 (page 72) lists several fungicides and their modes of action to help in resistance management.

Bactericides (copper and antibiotic compounds) can help reduce the risk of early-season bacterial disease epidemics, but are most effective when used with other control methods. Copper compounds also are mediocre fungicides and are handled similar to protectant fungicides. Antibiotics serve a similar purpose in certain crops.

Nematicides and fumigants are designed to reduce nematode and soilborne fungus populations before crops are planted. Like other disease-control chemicals, they are most effective when combined with cultural control options such as extended crop rotations and resistant varieties.

Table 29: Summary of Cultural Management Strategies for Disease

This table describes several diseases listed by crop. This list is not exhaustive, but represents important Midwest diseases. Also listed are the cultural management options available for each disease. The management options are described in more detail in the text. Note that some pathogens have races. The reaction of a particular race of fungus or bacterium will depend on the cultivar or variety grown. Rotation refers to the number of years that the field should be planted to a different crop.

Crop	Disease	Tillage[1]	Seedborne	Rotation	Resistance	Comments
Cabbage	Alternaria Leaf Spot	3	Yes	3-4	No	
	Black Rot	3	Yes	2-3	No	
	Yellows	2	Yes	>6	Yes	Fusarium fungus is soilborne.
Cantaloupe	Alternaria Leaf Blight	3	No	2	No	
	Anthracnose	3	Yes	2	No	
	Bacterial Wilt	1	No	NE[2]	No	Spread by cucumber beetles.
	Gummy Stem Blight	3	Yes	3	No	Also affects pumpkin, watermelon.
	Phytophthora Blight	2	No	>3	No	Water management is important. Avoid rotations with solanaceous crops.
	Powdery Mildew	2	No	2	Yes	
	Root Knot	2	No	>6	No	Wide host range.
Carrot	Alternaria Leaf Blight	3	Yes	2	Yes	
	Bacterial Blight	3	Yes	2-3	No	
Cucumber	Angular Leaf Spot	3	Yes	2	Yes	
	Anthracnose	3	Yes	2	Yes	Race 1 affects cucumber.
	Bacterial Wilt	1	No	NE[2]	No	Spread by cucumber beetles.
	Phytophthora Blight	2	No	>3	No	Water management is important. Avoid rotations with solanaceous crops.
	Scab	3	Yes	3	Yes	Favored by cool (<70°F), wet weather.
Pepper	Anthracnose	3	Yes	3	No	
	Bacterial Spot	3	Yes	2	Yes	Races.
	Phytophpthora	2	Yes	3	Yes	Races.
	PVY	1	No	2	Yes	Aphid transmission (reflective mulch).
	TEV	1	No	2	Yes	Aphid transmission (reflective mulch).
	TMV	1	No	2	Yes	Mechanical transmission.
Potato	Early Blight	3	No	3-4	Partial	More disease on early maturing cultivars.
	Late Blight	1	Yes	2-3	Partial	Survives on cull piles and volunteers.

continued next page

Table 29: Summary of Cultural Management Strategies for Disease (continued)

Crop	Disease	Tillage1	Seedborne	Rotation	Resistance	Comments
Pumpkin	Angular Leaf Spot	3	Yes	2	No	Symptoms similar to bacterial spot.
	Bacterial Spot	3	Yes	2	No	Also affects squash.
	Black Rot	3	Yes	2	No	Same as gummy stem blight on cantaloupe, watermelon.
	Downy Mildew	1	No	NE[2]	No	The causal fungus must blow into the Midwest from the southern United States.
	Fusarium Fruit Rot	2	Yes	>4	No	See comments in cucurbit section.
	Phytophthora Blight	2	No	>4	No	Water management is an important tool. Avoid rotations with Solanaceous crops.
	Plectosporium Blight	3	No	3-4	No	May be managed like black rot.
	Powdery Mildew	2	No	2	Partial	
	Virus Diseases (several)	1	No	NE[2]	No	Aphids spread virus. All cucurbits affected. Pumpkins planted by June 20 (southern Indiana) set fruit before disease becomes severe.
Snap Bean	Rhizoctonia Root Rot	3	No	NE[2]	No	Deep plow residue.
	White Mold	1	No	5-6	No	Wide host range. Manage water. Avoid rotation with soybean.
Sweet Corn	Stewart's Wilt	1	Yes	NE[2]	Partial	Spreads and survives in flea beetles.
Tomato	Anthracnose	3	Yes	2-3	No	Stake and mulch.
	Bacterial Spot	3	Yes	2-3	No	
	Canker	3	Yes	3-4	No	
	Early Blight	3	Yes	3-4	Partial	Some resistance to stem canker.
	Fusarium Crown Rot	2	No	>6	No	
	Fusarium Wilt	2	Yes	>6	Yes	Three races exist.
	Late Blight	1	No	NE	No	Does not overwinter in the Midwest.
	Leaf Mold	2	No	2	Yes	Many races of the fungus exist.
	Powdery Mildew	2	No	2	No	
	Root Knot	2	No	>6	Yes	Wide host range.
	Septoria Leaf Spot	3	No	2-3	No	
	Southern Blight	3	No	>6	No	Favors high temperatures.
	Speck	3	Yes	2	Yes	
	TMV	1	No	2	Yes	Can be spread by contact.
	Verticillium	2	No	>6	Yes	
	White Mold	1	No	5-6	No	*Wide host range.*
Vegetables (all)	Damping Off	1	No	NE[2]	No	Warm soils, greenhouse sanitation.
Watermelon	Anthracnose	3	Yes	3	No	Race 2 affects watermelon.
	Bacterial Fruit Blotch	3	Yes	2	No	Volunteer watermelon and cucurbit weeds can spread disease next season.
	Fusarium Wilt	2	Yes	>6	Partial	Three races exist.
	Gummy Stem Blight	3	Yes	3	No	Also affects cantaloupe, pumpkin, and squash.
	Phytophthora Blight	2	No	>3	No	Water management is important. Avoid rotations with solanaceous crops.
	Root Knot	2	No	>6	No	Wide host range.
Broadleaf Vegetables	Sclerotinia	2	No	With grasses 3-4	No	Flood. 23-45 days.

[1]1=tillage has limited effect, 2=tillage is of limited help, 3=tillage is an important control

[2]NE=not effective

Table 30: Preharvest Intervals (Days) and Re-Entry Intervals for Fungicides Registered for Use on Midwest Vegetables in 2015[a]

	Actigard®	Agri-Fos®, Fosphite®, Prophyte®	Aliette®	Aproach®	Bravo®, Echo®, Equus®	Cabrio®	Dithane®, Manzate®, Penncozeb®	Endura®	fixed copper	Flint®	Fontelis®	Forum®	Inspire Super®	Kumulus®	Merivon®	Monsoon®, Onset®, Toledo®	Presidio®	Previcur Flex®	Pristine®	Procure®	Propimax®, Tilt®	Quadris®, Satori®	Quadris Top®	Quintec®	Rally®	Ranman®	Revus®	Revus Top®	Rovral®	Switch®	Tanos®	Topsin M®	Torino®	Zampro®
Asparagus		b	110		190					180				0		180						100			180								
Bean, Dry		0		14	14			21	0					0		14					7	14							c	7		28		
Bean, Green		0		14	7			7	0		0			0		7					7	0			0	0	1		c	7		14		
Beet									0	7	0			0		7	7				14	0								7				
Broccoli	7	0	3		7	0		0	0		0	0	7	0		7	2			1		0	1			0	1		0	7				0
Brussels Sprouts	7	0	3		7	0		0	0		0	0	7	0			2			1		0	1			0	1			7				0
Cabbage	7	0	3		7	0		0	0		0	0	7	0		7	2			1		0	1			0	1			7				0
Cabbage, Chinese	7	0	3		7	3		d	0		0	e	7			7	2			1		0	1			0	1			7				0
Cantaloupe	0	0	1/2		0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0		1	1	3	0	0	0			1	3	1	0	0
Carrot		0			0	0		0	0	7	0			0	7				0		14	0	7			14			0	7				
Cauliflower	7	0	3		7	0		0	0		0	0	7	0			2			1		0	1			0	1			7				0
Celery		0	3		7	0		0	0	7	3	0		0			2				14	0					1			0	1			0
Collard	7	0	3			3		14	0		0	0	7	0		7				1		0	1			0	1			7				0
Cucumber	0	0	1/2		0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0		1	1		0	0	0			1	3	1	0	0
Eggplant		0			3	0		0	0	3	0	0	0	0			2					0	0		0	0	1			0				4
Endive		0	3			0			0		3	0					2			0		0				0				0	1			0
Kale	7	0	3			3		14	0		0	0	7	0		7				1		0	1			0	1			7				0
Lettuce, Head	7	0	3			0		14	0		3	0		0	1		2	2		0		0		1	3	0	1		14	0	1			0
Lettuce, Leaf	7	0	3			0		14	0		3	0		0	1		2	2		0		0		1	3	0	1		14	0	1			0
Mint					80									0							7	7			30									
Mustard	7	0	3			3		14	0		0	0	7			7				1		0	1			0	1			7				0
Onion, Bulb	7	0	7		7	7	7	7	0		3	0	7	0	7	7	2		7		14	0	7				7		7	7	3	b		0
Onion, Green		0			14	7		7	0		3	0	14	0	7	7	2		7		0	0	7				7			7	3			0
Parsley		0	3			0			0	7	3	0					2			0	14	0				0	1			0	1			0
Parsnip					10	0				7							7					0								7				
Peas		0						f	0					0								0												
Pepper	14g	0			3	0		0	0	3	0	0	0	0			2	5				0	0	3	0	0	1			0	3			4
Potato		0			7	3	14	10	0	7		4		0				14				14	14			7		14	14		14	21		4
Pumpkin	0	0	1/2		0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0		1	1	3	0	0	0			1	3	1	0	0
Radish	7					0				7	0				7		7					0								7				
Spinach	7	0	3			0			0		3	0			1		2					0	1			0	1			0	1			0
Squash, Summer	0	0	1/2		0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0		1	1		0	0	0			1	3	1	0	0
Squash, Winter	0	0	1/2		0	0		0	0	0	1	0	7	0	0	7	2	2	0	0		1	1	3	0	0	0			1	3	1	0	0
Sweet Corn				7	14		7		0							7					14	7												
Tomato	14	0	14		0	0	5	0	0	3	0	4	0	0			2	5				0	0		0	0	1	1		0	3			4
Turnip	7					0			0	7	0	b	b	0		7	7			1		0								7				
Watermelon	0	0	1/2		0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0		1	1	3	0	0	0			1	3	1	0	0
Re-Entry Interval (hr)	12	4	12	12	12	12	24	12	48	12	12	12	12	24	12	b	12	12	12	12	12	4	12	12	24	12	4	12	24	12	12	b	4	12

[a]Check label directions before applying any of these pesticides.
[b]See label.
[c]Do not apply past peak bloom.
[d]0-day PHI for Napa Chinese cabbage. 14-day PHI for bok choy.
[e]0-day PHI for bok choy. 7-day PHI for napa.
[f]Succulent only. 7-day PHI.
[g]Chile only.

Table 31: Common Names of Registered Fungicides

Common Name	Trade Name	Producer	Formulation[1,2]
acibenzolar-S-methyl	Actigard®	Syngenta	50WG
Ametoctradin/dimethomorph	Zampro®	BASF	1.88 SC
fosetyl-Al	Aliette®	Bayer Crop Science	80WP
azoxystrobin	Quadris®	Syngenta	2.08SC
	Satori®	Loveland Products	2.08SC
azoxystrobin, chlorothalonil	Quadris Opti®	Syngenta	0.5+5.0F
azoxystrobin, propiconazole	Quilt®	Syngenta	0.62+1.04F
boscalid	Endura®, Pristine®	BASF	70WG, 38WG
Bacillus subtillus QST 713	Serenade Max®	AgraQuest	WP
chlorothalonil	Bravo 500®	Syngenta	500F
	Bravo Ultrex®	Syngenta	82.5DG
	Bravo Weather Stik®	Syngenta	720F
	Bravo Zn®	Syngenta	500F
	Equus®	Griffin	DF, 720F
	Echo®	Sipcam	720F
Coniothyrium minitans	Contans®	Prophyta	5.3WG
copper hydroxide[3]	Kocide 2000®, 3000	Griffin	53, DF, 46 DF
	Champion®	Agtrol	50WP
	Champ®	Agtrol	4.5F
copper sulfate basic[3]	Basicop®	Griffin	53WP
	Cuprofix Disperse Ultra®	United Phosphorus, Inc.	20DF, 40DF
	Tribasic Copper® Sulfate®	Citco	53WP
copper resinate	Citcop 5E®	Tennessee Chemical	5EC (5%)
cymoxanil	Curzate DF®	DuPont	60DF
cymoxanil, famoxadone	Tanos®	Dupont	50WDG
cyazofamid	Ranman®	FMC	400 SC
cyprodinil/fludioxonil	Switch®	Syngenta	62.5 WG
dichloro-nitroaniline	Botran®	Gowan	75WP
difenoconazole	Inspire Super®	Syngenta	2.09SC
dimethomorph	Forum®	BASF	50WP, 4.18SC
fluazinam	Omega®	Syngenta	500F
fluopicolide	Presidio®	Valent	4SC
fluopyram/pyrimethanil	Luna Tranquility®	Bayer Crop Science	500SC
fluopyram/tebuconazole	Luna Experience®	Bayer Crop Science	400SC
fluopyram/trifloxystrobin	Luna Sensation®	Bayer Crop Science	500SC
fluxapyroxad/pyraclostrobin	Merivon®	BASF	500SC
	Priaxor	BASF	500SC
iprodione	Rovral®	Bayer Crop Science	50WP
kresoxim-methyl	Sovran®	BASF	50WG
mancozeb	Gavel®, Dithane M-45®, DF	Gowan	75DF, 80WP, 80DG
	Manzate 200DF®	Griffin	80 DG
	Penncozeb®	United Phosphorus, Inc.	80WP
	Penncozeb DF®	United Phosphorus, Inc.	75DF
mandipropamid	Revus®, Revus Top®	Syngenta	2.09SC
mefenoxam	Ridomil Gold Copper®	Syngenta	65WP
	Ridomil Gold Bravo®	Syngenta	76WP
	Ridomil Gold EC®	Syngenta	47EC
	Ridomil Gold MZ®	Syngenta	68WP
myclobutanil	Rally®	Dow Agroscience	40WSP
PCNB	Terrachlor®	Uniroyal Chemical	10DG, 75WP, 40F
penthiopyrad	Fontelis®	DuPont	1.67SC
phosphorous acid	Agri-Fos®	Agrichem	400FL
	Phostrol®	Nufarm	53.6 DF
	Prophyt®	Luxembourg	54.5 F
propamocarb	Previcur Flex®	Bayer Crop Science	66F
propiconazole	Tilt®, Propimax®	Syngenta, Dow Agroscience	3.6F
pyraclostrobin	Cabrio®, Headline EC®, Pristine®	BASF	20EG, 2.09EC, 38WG
pyrimethanil	Scala®	Bayer Crop Science	55SC
quinoxyfen	Quintec®	Dow Agroscience	2.08SC
tebuconazole	Monsoon®, Toledo®, Onset®	Loveland, Rotam	3.6F
thiophanate methyl	Topsin M®	United Phosphorus, Inc.	70WSB
trifloxystrobin	Flint®	Bayer Crop Science	50WDG
	Gem®	Bayer Crop Science	25WDG, 500SC
triflumizole	Procure®	Chemtura	480SC
zoxamide	Gavel 75DF®	Dow Agroscience	75DF

[1]DF=dry flowable, DG=dispersible granules, EC=emulsifiable concentrate, F=flowable suspension, LC=liquid concentrate, SC=soluble concentrate, WP=wettable powder, WSB=water soluble bag

[2]Fungicides are sold commercially as a mixture of active ingredient (that which kills the fungus) and other substances (i.e., carriers, diluents, solvents, wetting agents, emulsifiers, etc.). The formulation indicates the portion of the product that is active ingredient and the physical form of the product. For WP and DG formulations, the number before the abbreviation indicates the percentage of the product that is active ingredient. For example, "50WP" describes a wettable powder that is 50% active ingredient, and "4F" describes a flowable product that contains 4 lbs. of active ingredient per gallon of product.

[3]The number preceding the type of formulation for copper products indicates the percentage or amount of metallic copper in the product. For example, "53WP" describes a wettable powder product that is 53% metallic copper, and "4.5F" describes a flowable product containing 4.5 lbs. of metallic copper per gallon.

Table 32: Fungicide Resistance Management

Disease-causing fungi may become resistant to fungicides if label precautions are not followed carefully. This table is designed to help growers alternate applications between fungicides with different modes of action to avoid or delay development of fungicide resistance in fungi. Many product labels use the same letters and numbers as those listed in the MOA Code column below. This list is not exhaustive, but does contain many of the fungicides used in the Midwest.

Trade Names	Common Name	Risk of Resistance	MOA Code[1]
Actigard®	acibenzolar-S-methyl	none-low	21[2]
Agri-Fos®, Phostrol®	phosphorous acid	low	NA[3]
Aliette®	fosetyl-A1	low	33
Bravo®, Echo®, Equus®	chlorothalonil	none-low	M[4]
Cabrio®, Headline®	pyraclostrobin	high	11
copper (several)	copper	none-low	M
Curzate®	cymoxanil	medium-high	27
Dithane®, Manzate®, Penncozeb®	mancozeb/maneb	none-low	M
Endura®	boscalid	medium	7
Flint®, Gem®	trifloxystrobin	high	11
Fontelis®	penthiopyrad	medium-high	7
Forum®	dimethomorph	medium-high	40
Gavel®	mancozeb (M) + zoxamide (22)	low-medium	M, 22
Inspire Super®	cyprodinil (9) + difenoconazole (3)	medium	9, 3
Kumulus DF®, Microthiol®, Thiolux Jet®	sulfur	none-low	M
Luna Experience®	fluopyram (7) + tebuconazole (3)	medium	7, 3
Luna Sensation®	fluopyram (7) + trifloxystrobin (11)	medium	7, 11
Luna Tranquility®	fluopyram (7) + pyrimethanil (9)	medium	7, 9
Merivon ®	fluxapyroxad (11) + pyraclostrobin (7)	Medium-high	7, 11
Monsoon®, Onset®, Toledo®,	tebuconazole	medium	3
Omega®	fluazinam	low	29
Presidio®	fluopicolide	medium-high	43
Previcur Flex®	propamocarb	low-medium	28
Priaxor®	fluxapyroad (7) + pyraclostrobin (11)	Medium-high	7, 11
Pristine®	boscalid (7) + pyraclostrobin (11)	medium-high	7, 11
Procure®	triflumizole	medium	3
Quadris®, Satori®	azoxystrobin	high	11
Quadris Top®	azoxystrobin (11) + difenoconazole (3)	medium-high	11, 3
Quintec®	quinoxyfen	medium	13
Rally®	myclobutanil	medium	3
Ranman®	cyazofamid	medium-high	21
Reason®	fenamidone	high	11
Revus®	mandipropamid	medium-high	40
Revus Top®	mandipropamid difenoconazole	low-medium	40 3
Ridomil®	mefenoxam	high	4
Rovral®	iprodione	medium	2
Scala®	pyrimethanil	medium	9
Switch®	cyprodinil (9) + fludioxonil (12)	low-medium	9, 12
Tanos®	cymoxanil (27) + famoxadone (11)	medium	27, 11
Tilt®	propiconazole	medium	3
Topsin M®	thiophanate-methyl	high	1
Torino®	cyflufenamid (U6)	low moderate	U6
Zampro®	ametoctradin/ dimethomorph	medium	45, 40
Ziram®	ziram	none-low	M

[1]MOA=mode of action, or FRAC code.
[2]Fungicides with a numbered MOA code have very specific activity sites and may cause resistance to develop in fungi. These fungicides should be alternated with fungicides with different MOA codes. Read product labels to determine resistance management strategies.
[3]NA=not available.
[4]M=multi-site activity. Fungicides with mode of action code M are contact fungicides. It is not necessary to alternate these fungicides for resistance management.

Disease Management with the MELCAST System

MELCAST is a disease warning system that can help Indiana farmers schedule their fungicide applications for control of certain diseases of watermelons and cantaloupes. The system was developed by researchers in the Purdue University Department of Botany and Plant Pathology.

MELCAST is available throughout the summer at:

melcast.info

and

(800) 939-1604

Each winter, Purdue Extension plant pathology specialists conduct educational programs that address the system. For more information about MELCAST, see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST,* available from the Purdue Extension Education Store, www.the-education-store.com; or contact Dan Egel (Southwest Purdue Agricultural Research Program) at (812) 886-0198 or egel@purdue.edu.

Slug and Snail Control

Occasionally, slugs and snails seriously damage seedlings; tender, low-growing leafy vegetables; or ripening fruit that are on the ground. Slug and snail feeding damage (hollowed-out areas) can be found anywhere on fruit, but is usually concentrated near the stem. Slugs leave behind telltale slime trails (silvery trails) on the surfaces of fruit or leaves. Slugs and snails are active at night or cloudy days.

Slugs and snails favor continuously moist soil and organic mulch. They lay eggs in groups in moist soil, and overwinter in organic mulch. Slugs can complete their entire life cycle in a field.

If slugs are a problem, their hiding places (i.e., boards, stones, weedy areas), should be eliminated. Heavy mulching creates favorable slug habitats, so should be thinned so the soil can become warm and dry. Raised beds that can dry out more readily than flat beds reduce slug problems. Using black plastic mulch discourages slug build-up because it causes the soil to heat up and dry out.

As a last resort, metaldyhyde bait (e.g., Clean Crop, 3.5G® at 30-40 lbs./A or Clean Crop 7.5G® at 15-20 lbs./A) can be used and is usually very effective. Follow label instructions carefully for application methods for each particular vegetable crop. Apply bait in evening after a rain or irrigation. An organic alternative to metaldehyde is iron phosphate. Baits containing iron phosphate are sold under the trade name Sluggo® (and others) and are only slightly less effective than metaldehyde baits.

Slugs and snails prefer moist soils and plenty of organic matter.

Table 33: Common and Scientific Vegetable Pest Names

The names in this table represent the common and scientific (Latin) names of all the pests represented in this guide. The names are provided to help users interpret information presented in pesticide labels and other sources.

Insects		
Common Name	**Scientific Name**	**Order**
armyworm	*Mythimna (Pseudaletia) unipuncta*	Lepidoptera
asparagus aphid	*Brachycorynella asparagi*	Hemiptera
asparagus beetle	*Crioceris asparagi*	Coleoptera
asparagus miner	*Ophiomyia simplex*	Diptera
aster leafhopper	*Macrosteles quadrilineatus*	Hemiptera
bandedwinged whitefly	*Trialeurodes abutiloneus*	Hemiptera
bean aphid	*Aphis fabae*	Hemiptera
bean leaf beetle	*Cerotoma trifurcata*	Coleoptera
bean seed maggot	*Delia florilega*	Diptera
beet armyworm	*Spodoptera exigua*	Lepidoptera
black cutworm	*Agrotis ipsilon*	Lepidoptera
brown marmorated stink bug	*Halymorpha halys*	Hemiptera
brown stink bug	*Euschistus servus*	Hemiptera
cabbage aphid	*Brevicoryne brassicae*	Hemiptera
cabbage looper	*Trichoplusia ni*	Lepidoptera
cabbage maggot	*Delia radicum*	Diptera
carrot weevil	*Listronotus oregonensis*	Coleoptera
celery leaftier	*Udea rubigalis*	Lepidoptera
Colorado potato beetle	*Leptinotarsa decemlineata*	Coleoptera
corn earworm bollworm tomato fruitworm	*Helicoverpa zea*	Lepidoptera
corn flea beetle	*Chaetocnema pulicaria*	Coleoptera
corn leaf aphid	*Rhopalosiphum maidis*	Hemiptera
cross-striped cabbageworm	*Evergestis rimosalis*	Lepidoptera
crucifer flea beetle	*Phyllotreta cruciferae*	Coleoptera
diamondback moth	*Plutella xylostella*	Lepidoptera
eastern field wireworm	*Limonius agonus*	Coleoptera
eggplant flea beetle	*Epitrix fuscula*	Coleoptera
European corn borer	*Ostrinia nubilalis*	Lepidoptera
fall armyworm	*Spodoptera frugiperda*	Lepidoptera
flower thrips	*Frankliniella tritici*	Thysanoptera
garden webworm	*Achyra rantalis*	Lepidoptera
golden tortoise beetle	*Charidotella (Metriona) sexpunctata bicolor*	Coleoptera
green cloverworm	*Hypena (Plathypena) scabra*	Lepidoptera
green peach aphid	*Myzus persicae*	Hemiptera
green stink bug	*Acrosternum hilare*	Hemiptera
harlequin bug	*Murgantia histrionica*	Hemiptera
horseradish flea beetle	*Phyllotreta armoraciae*	Coleoptera
imported cabbageworm	*Pieris rapae*	Lepidoptera
melon aphid/cotton aphid	*Aphis gossypii*	Hemiptera
Mexican bean beetle	*Epilachna varivestis*	Coleoptera
northern corn rootworm	*Diabrotica barberi*	Coleoptera
onespotted stink bug	*Euschistus variolarius*	Hemiptera
onion maggot	*Delia antiqua*	Diptera
onion thrips	*Thrips tabaci*	Thysanoptera
palestriped flea beetle	*Systena blanda*	Coleoptera
pea aphid	*Acyrthosiphon pisum*	Hemiptera
potato aphid	*Macrosiphum euphorbiae*	Hemiptera
potato flea beetle	*Epitrix cucumeris*	Coleoptera
potato leafhopper	*Empoasca fabae*	Hemiptera
purplebacked cabbageworm	*Evergestis pallidata*	Lepidoptera
rhubarb curculio	*Lixus concavus*	Coleoptera
saltmarsh caterpillar	*Estigmene acrea*	Lepidoptera
seedcorn maggot	*Delia platura*	Diptera
serpentine leafminer	*Liriomyza brassicae*	Diptera
soybean thrips	*Neohydatothrips variabilis*	Thysanoptera
spinach flea beetle	*Disonycha xanthomelas*	Coleoptera
spinach leafminer	*Pegomya hyoscyami*	Diptera
spotted asparagus beetle	*Crioceris duodecimpunctata*	Coleoptera
spotted cucumber beetle southern corn rootworm	*Diabrotica undecimpunctata howardi*	Coleoptera
squash bug	*Anasa tristis*	Hemiptera
squash vine borer	*Melittia cucurbitae*	Lepidoptera
stalk borer	*Papaipema nebris*	Lepidoptera
striped cucumber beetle	*Acalymma vittatum*	Coleoptera
striped flea beetle	*Phyllotreta striolata*	Coleoptera
sugarbeet wireworm	*Limonius californicus*	Coleoptera
sweetpotato flea beetle	*Chaetocnema confinis*	Coleoptera
sweetpotato weevil	*Cylas formicarius elegantulus*	Coleoptera
tarnished plant bug	*Lygus lineolaris*	Hemiptera
tobacco hornworm	*Manduca sexta*	Lepidoptera
tomato hornworm	*Manduca quinquemaculata*	Lepidoptera
turnip aphid	*Lipaphis pseudobrassicae*	Hemiptera
twospotted spider mite	*Tetranychus urticae*	Acari
variegated cutworm	*Peridroma saucia*	Lepidoptera
vegetable leafminer	*Liriomyza sativae*	Diptera
western bean cutworm	*Striacosta (Loxagrotis) albicosta*	Lepidoptera
western corn rootworm	*Diabrotica virgifera virgifera*	Coleoptera
yellow woollybear	*Spilosoma virginica*	Lepidoptera
zebra caterpillar	*Melanchra picta*	Lepidoptera

Weeds		
Common Name	**Scientific Name**	**Family**
barnyardgrass	*Echinochloa crus-galli*	Poaceae
black nightshade	*Solanum nigrum*	Solanaceae
common lambsquarters	*Chenopodium album*	Chenopodiaceae
common purslane	*Portulaca oleracea*	Portulacaceae
common ragweed	*Ambrosia artemisiifolia*	Asteraceae
common waterhemp	*Amaranthus rudis*	Amaranthaceae
crabgrass	*Digiteria sanguinalis*	Poaceae
eastern black nightshade	*Solanum ptycanthum*	Solanaceae
entireleaf morningglory	*Ipomoea hederacea*	Convolvulaceae
fall panicum	*Panicum dichotomiflorum*	Poaceae
giant foxtail	*Setaria faberi*	Poaceae
giant ragweed	*Ambrosia trifida* L.	Asteraceae
goosegrass	*Eleusine indica*	Poaceae
green foxtail	*Setaria viridis*	Poaceae
hairy galinsoga	*Galinsoga ciliate*	Asteraceae
ivyleaf morningglory	*Ipomoea hederacea*	Convolvulaceae
jimsonweed	*Datura stramonium*	Solanaceae

Weeds		
Common Name	**Scientific Name**	**Family**
ladysthumb	*Polygonum persicaria*	Polygonaceae
Pennsylvania smartweed	*Polygonum pensylvanicum*	Polygonaceae
redroot pigweed	*Amaranthus retroflexus*	Amaranthaceae
smooth pigweed	*Amaranthus hybridus*	Amaranthaceae
tall morningglory	*Ipomoea purpurea*	Convolvulaceae
velvetleaf	*Abutilon theophrasti*	Malvaceae
yellow foxtail	*Setaria pumila*	Poaceae
yellow nutsedge	*Cyperus esculentus*	Cyperaceae

Diseases		
Disease	**Pathogen**	**Host Crop**
Alternaria leaf blight of cucurbits	*Alternaria cucumerina*	cucurbits
Alternaria leaf blight of carrots	*Alternaria dauci*	carrot
Alternaria leaf spot of beet	*Alternaria alternata, brassicae*	beet
Alternaria leaf spot of cole crops	*Alternaria brassicae*	cole crops
angular leaf spot	*Pseudomonas syringae* pv. *lachrymans*	cucurbits
anthracnose of cucurbits	*Colletotrichum orbiculare*	cucurbits
Anthracnose of corn	*Colletotrichum graminicola*	sweet corn
Anthracnose of legumes	*Colletotrichum lindemuthiana*	Legumes
Anthracnose of pepper/ tomato	*Colletotrichum* spp.	pepper, tomato
Ascochyta leaf spot	*Ascochyta rhei*	rhubarb
aster yellows of carrot	*Phytoplasma* sp.	carrot
aster yellows of potato	*Phytoplasma* spp.	Potato
bacterial blight	*Xanthomonas axonopodis pv. allii*	onion
bacterial canker	*Clavibacter michiganensis* subsp. *michiganensis*	tomato
bacterial fruit blotch	*Acidovorax citrulli*	cucurbits
bacterial leaf and fruit spot	*Xanthomonas cucurbitae*	cucurbits
bacterial speck	*Pseudomonas syringae* pv. *tomato*	tomato
bacterial spot	*Xanthomonas campestris* pv. *vesicatoria*	pepper, tomato
bacterial wilt	*Erwinia tracheiphila*	cucurbits
basal rot of garlic/ onion	*Fusarium culmorum*	garlic
bean yellow mosaic	*Bean yellow mosaic virus*	legumes
black dot	*Colletotrichum coccodes*	potato
black leg of cole crops	*Phoma lingam*	cole crops
black rot of sweet potato	*Ceratocystis fimbriata*	sweet potato
black rot of cole crops	*Xanthomonas campestris* pv. *campestris*	cole crops
blackleg	*Erwinia carotovora* subsp. *atroseptica*	potato
Botrytis leaf blight	*Botrytis squamosa*	onion
Botrytis neck rot	*Botrytis allii*	onion
Botrytis gray mold	*Botrytis cinerea*	lettuce, spinach, tomato, legumes
bottom rot/damping-off	*Rhizoctonia solani*	lettuce

Diseases		
Disease	**Pathogen**	**Host Crop**
buckeye rot	*Phytophthora* spp.	tomato
canker/black scurf	*Rhizoctonia solani*	potato
Cercospora blight	*Cercospora asparagi*	asparagus
Cercospora leaf spot	*Cercospora belicolia*	beet
chlorotic dwarf	*Maize chlorotic dwarf virus*	sweet corn
club root	*Plasmodiophora brassicae*	cole crops
common bacterial blight	*Xanthomonas campestris* pv. *phaseoli*	legumes
common rust	*Puccinia sorghi*	sweet corn
crown and root rot	*Fusarium oxysporum* f. sp. *asparagi*	asparagus
crown and spear rot	*Phytophthora megasperma*	asparagus
cucumber mosaic	*Cucumber mosaic virus*	cucurbits, pepper,
cyst nematode disease	*Heterodera glycines*	legumes
damping-off	*Pythium* spp.	cilantro, dill, legumes, lettuce, parsley, parsnip, spinach, and other vegetables
downy mildew of lettuce	*Bremia lactucae*	lettuce
downy mildew of cole crops	*Hyaloperonospora parasitica*	cole crops
downy mildew of basil	*Peronospora belbahrii*	basil
downy mildew of garlic/onion	*Peronospora destructor*	garlic, onion
downy mildew of spinach	*Peronospora farinosa*	spinach
downy mildew of beet	*Peronospora farinose* f. sp. *betae*	beet
downy mildew of dill/ parsnip	*Peronospora umbellifarum*	dill, parsnip
downy mildew of cucurbits	*Pseudoperonospora cubensis*	cucurbits
drop (Sclerotinia rot)	*Sclerotinia sclerotiorum*	lettuce
dry rot	*Fusarium solani*	potato
dwarf mosaic	*Maize dwarf mosaic virus*	sweet corn
early blight of tomato	*Alternaria solani*	potato, tomato
foot rot of tomato	*Fusarium solani*	tomato
foot rot of sweet potato	*Plenodomus destruens*	sweet potato
fruit rot of cucurbits	*Fusarium solani* f. sp. *cucurbitae*	cucurbits
Fusarium wilt of basil	*Fusarium oxysporum* f. sp. *basilicum*	basil
Fusarium wilt of watermelon	*Fusarium oxysporum* f. sp. *niveum*	watermelon
Fusarium wilt of sweet potato	*Fusarium oxysporum* f. sp. *batatas*	sweet potato
Fusarium wilt of tomato	*Fusarium oxysporum* f. sp. *lycopersici*	tomato
Fusarium wilt of legumes	*Fusarium oxysporum* f. sp. *phaseoli*	legumes
Fusarium wilt of okra	*Fusarium oxysporum* f. sp. *vasinfectum*	okra
gray leaf spot	*Cercospora zeae-maydis*	sweet corn
gummy stem blight/ black rot	*Didymella bryoniae*	cucurbits
late blight	*Phytophthora infestans*	potato, tomato
leaf mold	*Fulvia fulva*	tomato
lettuce mosaic	*Lettuce mosaic virus*	lettuce

Diseases		
Disease	**Pathogen**	**Host Crop**
northern corn leaf spot	*Bipolaris zeicola*	sweet corn
northern leaf blight	*Exserohilum turcicum*	sweet corn
Phytophthora blight	*Phytophthora capsici*	cucurbits, solanaceous
Plectosporium blight	*Plectosporium tabacinum*	cucurbits
potato virus X	*Potato virus x*	potato
potato virus Y	*Potato virus y*	potato
powdery mildew of lettuce	*Erysiphe cichoracearum*	lettuce
powdery mildew of cole crops	*Erysiphe cruciferarum*	cole crops
powdery mildew of carrot	*Erysiphe heraclei*	carrot, cilantro, dill, parsley, parsnip
powdery mildew of pepper/tomato	*Leveillula taurica*	pepper, tomato
powdery mildew of cucurbits	*Podosphaeria xanthii*	cucurbits
purple blotch	*Alternaria porri*	onion, garlic, leek
Rhizoctonia diseases	*Rhizoctonia solani*	cole crops
ring rot	*Clavibacter michiganensis subsp. sepedonicus*	potato
ringspot	*Papaya ringspot virus*	cucurbits
root and crown rot	*Phytophthora* spp.	rhubarb
root knot	*Meloidogyne* spp.	beet, carrot, cucurbits, potato,
root lesion	*Pratylenchus* spp.	potato
rust of asparagus	*Puccinia asparagi*	asparagus
rust of legumes	*Uromyces appendiculatus*	legumes
scab of cucurbits	*Cladosporium cucumerinum*	cucurbits
scab of potato	*Streptomyces scabies*	potato
scurf	*Monilochaetes infuscans*	sweet potato
Septoria blight of parsley	*Septoria petroselini*	parsley
Septoria leaf blight of tomato	*Septoria lycopersici*	tomato
Septoria leaf spot of mint	*Septoria menthae*	mint
silver scurf	*Helminthosporium solani*	potato
slippery skin	*Pseudomonas gladioli* pv. *alliicola*	onion
smut of onion/leek	*Urocystis colchici*	onion, leek
smut of corn	*Ustilago maydis*	sweet corn
sour skin	*Pseudomonas cepacia*	garlic, onion
southern blight	*Sclerotium rolfsii*	eggplant, pepper, tomato
southern corn leaf blight	*Bipolaris maydis*	sweet corn
southern rust	*Puccinia polysora*	sweet corn
spearmint rust	*Puccinia menthae*	mint
squash mosaic	*Squash mosaic virus*	cucurbits
Stewart's wilt	*Erwinia stewartii*	sweet corn
tobacco mosaic	*Tobacco mosaic virus*	potato, tomato
tomato spotted wilt	*Tomato spotted wilt virus*	tomato
Verticillium wilt	*Verticillium dahliae, Verticillium albo-atrum*	eggplant, mint, potato, tomato
watermelon mosaic	*Watermelon mosaic virus*	cucurbits
wheat streak mosaic	*Wheat streak mosaic virus*	sweet corn

Diseases		
Disease	**Pathogen**	**Host Crop**
white mold (timber rot)	*Sclerotinia sclerotiorum*	carrot, cole crops, eggplant, legumes, mint, pepper, potato, tomato
white rot	*Sclerotium cepivorum*	garlic, leek, onion
white rust	*Albugo candida*	cole crops
yellows	*Fusarium oxysporum* spp.	cole crops
zucchini yellow mosaic	*Zucchini yellow mosaic virus*	cucurbits

Asparagus

Varieties

Hybrid varieties have improved vigor, disease tolerance, and higher yields, and are grown from seeds or crowns. All-male hybrids have higher yields and do not produce seed. Absence of seed production is desirable because seeds develop into volunteer asparagus seedlings that are a weed problem. Order hybrids well in advance.

All-male hybrids (listed in order of performance): Jersey General, Jersey Giant (56X22-8), Millenium, Jersey Knight, Jersey King, Jersey Supreme.

Other hybrids: Atlas, Purple Passion (specialty markets only).

Non-hybrids: Viking KB3, Mary Washington.

Planting and Spacing

Crowns: Use only 1-year old crowns. Transplant April 15 to May 15. Use 4- to 5-foot rows with crowns 12 to 16 inches apart. Set the crowns in 8-inch furrows in light soils and 5- to 6-inch furrows in heavy soils. Cover with 2 to 3 inches of soil. Select deep, well-drained sandy loam soils. Hybrids should be planted slightly deeper. Start cultivating when spears begin to emerge, and continue periodically until furrows are level at end of first season.

Seedling transplant: 10- to 14-week old seedling transplants can be mechanically transplanted. Apply 4 ounces of transplant solution (10-52-17 or 9-45-15) to each transplant. Transplant in either the spring or fall.

Harvesting

Harvest only 2 or 3 times in spring 1 year after transplanting. Thereafter, harvest for about 2 months in the spring. Harvest asparagus early in the morning for best quality. Allow the ferns to grow vigorously after this period to accumulate food reserves for the next season. As much care should be put into maintaining a healthy fern as into harvest.

Fertilizing

Lime: To maintain a soil pH of 6.7 to 7.0. If possible, apply lime the year before planting.

Preplant: N: 70 pounds per acre. P_2O_5: 25 to 200 pounds per acre. K_2O: 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Broadcast the fertilizer, and plow it under when preparing the land for the planting furrows. Before planting new crowns, apply 100 pounds per acre of 8-32-0, or similar high phosphate starter fertilizer, in the bottom of the trench. Cover with 1 inch of soil before setting crowns.

Yearly: Each year after harvest, apply 50 pounds N per acre by broadcasting and incorporate by lightly tilling. No P_2O_5 or K_2O is necessary if adequate fertilization was achieved prior to planting.

Disease Control

Fusarium Crown and Root Rot

Avoid fields with a history of crown and root rot. Disease is promoted by acid (low pH) and poorly drained soil. Use tolerant varieties if available.

Fields with Fuarium crown and root rot symptoms may benefit from applying 450 lbs./A of rock salt (NaCl) applied in the spring with fertilizers. Do not apply rock salt to healthy asparagus fields. Do not apply rock salt to fields with a pH less than 5.5.

Recommended Products

Manzate® at 1 lb. per 100 gallons of water for dry formulations, or at 0.8 qt. per 100 gallons of water for most liquid formulations.

Rust and Leaf Spot (Cercospora)

Reduce crop residues by removing, mowing, or burning old ferns in the fall/winter.

Recommended Products

Bravo®, **Echo®**, **Equus®**, and **Initiate®** are labeled for use at various rates. 190-day PHI.

Dithane®, **Manzate®**, or **Penncozeb®** at 2 lbs. per acre for dry (WP, DF, or DG) formulations or 1.6 qts. per acre for flowable (F) formulations. 180-day PHI.

Monsoon 3.6F®, **Onset®**, **Toledo 3.6F®** at 4-6 fl. oz. per acre. *Rust only*. 180-day PHI.

Rally 40WSP® at 5 oz. per acre. *Rust only*. 180-day PHI.

Phytophthora Crown and Spear Rot

Recommended Products

Agri-Fos®. See label for rate.

Aliette WDG® at 5 lbs. per acre. 110-day PHI.

Phostrol® at 2.5-5 pts. per acre.

Ridomil Gold SL® at 1 pt. per acre. 1-day PHI.

Weed Control

Before establishing an asparagus planting, reduce perennial weeds in the area to be planted. Good weed control in the planting year is especially important. Herbicide options are limited in the planting year, so cultivation and hand hoeing may be needed to achieve good control.

A typical weed control program in asparagus includes a preemergence herbicide with a long residual applied before asparagus emerges. If needed, a preemergence herbicide may be applied again after harvest is finished. Postemergence herbicides are also available — some may be applied before asparagus emerges, others may be applied during or after the harvest season, and some require directed or shielded spray applications to avoid spraying asparagus.

It is important use herbicides with different modes of action from year to year to avoid buildup of weed species not controlled by a particular mode of action. When herbicides are not used, weed control methods include cultivation, hand-weeding, flaming, mowing, and mulching. It is important to avoid damaging crowns when cultivating.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Preemergence Broadleaves and Grasses

Recommended Products

Chateau WDG® at 6 oz. per acre. Apply to dormant asparagus at least 2 weeks before spears emerge. Crop injury may result if asparagus is not dormant. May be tank mixed with paraquat to control emerged weeds. Do not exceed 6 oz. per acre per growing season.

Diuron products at 0.8-3 lbs. a.i. per acre. Use 80DF formulations at 1-4 lbs. per acre, or 4L formulations at 1.6-3 qts. per acre. Do not apply to young plants during first year. Use lower rates on light-colored soils with less than 2% organic matter. Apply after tillage or chopping fern in the spring and again after harvest, if necessary. 6-8 weeks residual activity. Do not exceed 6 lbs. per acre per year.

Prowl H2O® at 2.4-8.2 pts. per acre. Apply at least 14 days before first harvest and prior to spear emergence. If spears are present, remove before application. On sandy soil use no more than 2.4 pts. per acre. 14-day PHI.

Sencor 4F® at 0.5-2 qts. per acre, or **Sencor 75DF**® at 0.6-2.6 lbs. per acre. Do not apply to young plants during first year. Apply after tillage or chopping fern in the spring and again after harvest, if necessary. Use lower rates for split applications. 6-8 weeks residual activity. Do not exceed 2 qts. or 2.6 lbs. per acre per year. 2 sprays necessary for seasonlong sandbur control. 14-day PHI.

Sinbar 80W® at 0.62-1.5 lbs. per acre. *Established crowns or directed seeded plants only*. Do not use on sandy soil or on soil with less than 1% organic matter. Apply in spring after cutting fern and prior to spear emergence. For seeded crops apply activated charcoal at 300 lbs. per acre in a 1-inch band over the row before Sinbar® application. Do not plant other crops within 2 years of application. 8-12 weeks residual activity. 5-day PHI.

Solicam DF® at 2.5-5 lbs. per acre. Do not apply within 12 months of planting. Apply preemergence to soil free of weeds and debris. 14-day PHI.

Trifluralin products at 1-1.5 lbs. a.i. per acre. Use 4EC formulations at 1-1.5 qts. per acre. *Established plantings only*. Apply and incorporate 1-2 inches early in the spring when spears are at least 4 inches below soil surface. Use higher rates on heavier soils. 4-6 weeks residual activity.

Preemergence Broadleaves

Recommended Products

RR **Callisto 4L**® at 6-7.7 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year.

Lorox 50DF® at 2-4 lbs. per acre. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Maximum 4 lbs. or 3 applications per acre per year. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations that contain 3 lbs. ae/gal. (equivalent to 4 lbs. isopropylamine salt/gal.) at 1-5 qts. per acre; or formulations that contain 4.5 lbs. ae/gal. (equivalent to 5 lbs. potassium salt/gal.) at 0.66-3.3 qts. per acre. Apply to emerged weeds at least 7 days before spears emerge or immediately after the last harvest. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. If spears are allowed to regrow, delay application until ferns have developed. Delayed treatments must be applied as a directed or shielded spray. Direct contact of the spray with asparagus fern may result in serious crop injury.

Gramoxone Inteon2L® at 2.5-4 pts. per acre. Include 1 qt. of COC, or 4-8 fl. oz. of NIS per 25 gallons of spray solution. Apply before crop emergence or after last harvest before fern regrows. *RUP*. 6-day PHI.

Postemergence Broadleaves

Recommended Products

RR **Callisto 4L**® at 3 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. For postharvest applications use drop nozzles or other equipment that will minimize contact with crop. Adding COC or NIS (alone, or with UAN or AMS) will improve emerged weed control and increase crop injury risk in postharvest applications. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year.

2,4-D amine at 3-4 pts. per acre. Apply before, during, or after the harvest season. During harvest season apply immediately after cutting. Discard deformed spears. Use drop nozzles for treatments after harvest to avoid spraying the fern.

Clarity 4L® at 0.5-1 pt. per acre. Apply at 40-60 gals. per acre immediately after cutting. Discard crooked spears at harvest. Clarity® can injure nearby broadleaf crops and garden plants. Maximum 1 pt. per acre per year. 24-hour PHI.

Lorox 50DF® at 1-3 lbs. per acre and up to 3 applications for established beds. Apply before cutting season or immediately after cutting. For newly planted crowns apply 1-2 lbs. per acre, up to 2 applications when ferns are 6-18 inches tall. Do not use on sand, loamy sand, or soils with less than 1% organic matter. 1-day PHI.

Savage WSG® at 1.5-2 lbs. per acre. Apply before, during, or after the harvest season. During harvest season apply immediately after cutting. Discard deformed spears. Use drop nozzles for treatments after harvest to avoid spraying the fern.

Sandea 75W® at 0.5-1.5 oz. per acre. Apply before, during, or after harvest. Drop nozzles and using COC or NIS are recommended for applications after harvest. For first year transplants do not apply sooner than 6 weeks after fern emergence. Do not exceed 2 applications per crop cycle, or 2 oz. per acre per 12-month period. Has residual soil activity. Effective on nutsedge. 1-day PHI.

Postemergence Grasses

Recommended Products

Clethodim products at 0.068-0.125 lb. a.i. per acre. Use formulations with 0.97 lb. a.i. per gallon at 9-16 fl. oz. per acre. Use formulations with 2 lb. a.i. per gallon at 6-8 fl. oz. per acre. Use 1 qt. COC per 25 gallons of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 1-day PHI.

Fusilade DX 2E® at 8-12 fl. oz. per acre. Include 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gallons of spray solution. Spray on actively growing grass. Rates may be doubled if asparagus will not be harvested for 12 months. Wait at least 14 days between applications. Do not exceed 48 fl. oz. per acre per season on bearing asparagus. 1-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre, plus 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Herbicides for Asparagus[1]

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop					OK on Young Plantings?	Timing Relative to Weeds		Weed Groups Controlled			Comments
		Before spears emerge in spring	After final harvest before fern grows	During harvest period after cutting spears	Postemergence to ferns after harvest	Directed or shielded spray to ferns after harvest		Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	
Callisto 4L® (12h/-)	mesotrione	X	X			X		X	X		X	X	
Chateau® (12h/-)	flumioxazin	X					No	X		X	X	X	Apply at least 2 weeks before spears emerge.
Clarity 4L® (24h/1d)	dicamba			X					X		X	X	
Diuron®, others (12h/-)	diuron	X	X				No	X		X	X	X	
Fusilade DX 2E® (12h/1d)	fluazifop	X	X	X	X		Yes		X	X			
Gramoxone Inteon 2L® (12h to 24h/6d)	paraquat	X	X				yes		X	X	X	X	
Lorox 50DF® (12h/1d)	linuron	X	X		X		Yes	X	X		X	X	
Poast® (12h/1d)	sethoxydim	X	X	X	X		Yes		X	X			
Prowl H2O® (12h/14d)	pendimethalin	X						X		X	X		
Roundup®, others (12h/-)	glyphosate	X	X			X	yes		X	X	X	X	Apply at least 7 days before spears emerge.
Sandea® (12h/1d)	halosulfuron	X	X	X		X	Yes	X	X		X	X	Has activity against nutsedge.
Savage WSG®, others (48/h)	2,4-D amine	X	X	X		X			X		X	X	
Select Max®, others (12h/1d)	clethodim	X	X	X	X		Yes		X	X			
Sencor 4F® or 75DF (12h/14d)	metribuzin	X	X				No	X		X	X	X	
Sinbar® (12h/5d)	terbacil	X					No	X	X		X		Do not plant other crops for 2 years.
Solicam DF® (12h/14d)	norflurazon	X					No	X		X	X	X	
Treflan®, others (12h/-)	trifluralin	X					No	X		X	X		Incorporate.

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.

Insect Control

Asparagus Beetles and Cutworms

Treat when insects reach the economic thresholds described below.

Harvest

Asparagus Beetle

5-10% plants infested or

2% of spears with eggs

Cutworms

5% of crowns infested

Fern

Asparagus Beetle

10% defoliation or

50% of plants with larvae

Fall

Cutworms

1 larva per 20 plants

Recommended Products

For control on spears during harvest, to prevent egg laying and feeding injury:

Lannate SP® at 0.5-1 lb. per acre. Do not exceed 8 applications per crop. Use high rate for white cutworm. 1-day PHI. *RUP.*

Lorsban 4E® at 2 pts. per acre, or **Lorsban 75WG®** at 1.33 lbs. per acre. Do not make more than 1 preharvest application. Broadcast with ground equipment. 1-day PHI. *RUP.*

Malathion 57EC® at 1.5-2 pts. per acre. *Asparagus beetles only.* 1-day PHI.

Pounce 25WP® at 3.2-6.4 fl. oz. per acre. Do not exceed 0.4 lb. a.i. per season. 1-day PHI. *RUP.*

Sevin XLR PLUS® at 1 qt. per acre, or **Sevin 5B®** at 20 lbs. per acre. Do not treat more than once every 3 days. Bait for cutworms only. 1-day PHI.

For control on seedlings and fern growth after harvest is over (use lower rates for seedlings):

Dimethoate 400® or **Dimethoate 4E®** at 1 pt. per acre. *Asparagus beetles only.* Do not exceed 5 pts. per acre per year. 180-day PHI

RR **Entrust®** at 1.25-2.0 oz. per acre. *Asparagus beetles only.* Do not exceed 5.6 oz. per acre per season.
60-day PHI.

RR **Radiant SC®** at 4-8 fl. oz. per acre. *Asparagus beetles only.* Do not exceed 24 fl. oz. per acre per season.
60-day PHI.

Sevin XLR PLUS® at 2-4 qts. per acre. Do not treat more than once every 7 days. Do not exceed 5 applications per year to spears and ferns combined.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Harvest asparagus spears in the morning for best quality.

Asian Vegetables

U.S. demand for ethnic vegetables is increasing rapidly — from a growing ethnic Asian population and from health-conscious consumers seeking variety.

Asian vegetables are those that have originated from East Asia (China, Japan, and Korea) and Southeast Asia (Indonesia, Laos, the Philippines, Singapore, Thailand, Vietnam, etc.). Most Asian vegetables are not well-known to American farmers, because they are typically cultivated by the Asian growers exclusively for Asian-Americans. However, some of these Asian vegetables may be considered as options for Midwest producers.

The information below should be considered an introduction to Asian vegetables. More detailed information can be found in the resources section. General pest management recommendations for the crop families described below can be found in the corresponding crop chapters in this Guide. Although not all of the Asian vegetable crops mentioned in this chapter will be associated with pesticides in the crop chapters of this guide, more detailed information can be found on the pesticide label.

Marketing

Growers might consider Asian vegetables in double crop situations (such as following a wheat or early cabbage or sweet corn crop). Growers who want to diversify their farming operations by including Asian vegetables need to be very cautious before beginning production. Marketing information for Asian crops is not widely published. Since Asian crops are niche items, only specialized produce companies deal in them. Most of these buyers deal with restaurants, some chain stores, and specialty food stores.

Do your homework. Establish markets and buyers before buying any seed. Calculate budgets and collect economic data on any crop to determine its profit potential. And remember that all Asian crops are very labor intensive, so you will need a strong and dependable labor force for timely harvest and proper cultural management.

Common Asian Vegetables

Asian vegetables have different names in different languages. You must properly identify the crop to market it properly and to select the appropriate pest control measures.

Cole Crops and Brassica Leafy Greens

Includes Chinese cabbage (Napa cabbage and bok choy), daikon radish.

Chinese Cabbage (Napa cabbage and bok choy): Chinese cabbage has been grown in Asia since the 5th century. Chinese cabbage is a term applied to a wide range of types and varieties. The main types and varieties of Chinese cabbage are:

Group I: Napa cabbage, *Brassica campestris,* is commonly called the pe-tsai group. Its common names also include celery cabbage, Chinese white cabbage, Peking cabbage, pe-tsai, won bok, nappa (Japanese), hakusai (Japanese), pao, and hsin pei tsai. Napa cabbage includes broadleafed, compact-heading varieties of which there are two forms, Chihili and Che-foo.

Chihili forms of Napa cabbage form a cylindrical head 18 inches long and 6 inches in diameter, with an erect, upright growing habit. Some of the varieties of this form are Chihili, Michihli, Market Pride, Shantung, and Shaho Tsai.

Che-foo types form a compact, round head of green-bladed, white petioled leaves. Some varieties in this group are Che-foo, Tropical Pride, and Oriental King.

Group II: Bok choy, *Brassica campestris* is sometimes called *Brassica chinensis*. The most commonly accepted designations are bok choy or pak choy. Many refer to it as Chinese mustard.

Bok choy is a nonheading form of Chinese cabbage, with several thick white leafstalks. The smooth, glossy, dark green leaf blades form a celery-like cluster. There aren't as many varieties as there are of the Napa type: two are Canton Choice, and Long White Petiole.

Chinese cabbage is a cool-season annual vegetable. It grows best with short days and moderate to cool temperatures (60-70°F). Their cultural requirements are similar to those of cabbage and lettuce. Chinese cabbage is fairly quick in maturing. It varies from 40 days from sowing to harvest for some cultivars, to 75 days for the longer maturing ones. Space Napa cabbage 18 inches apart and bok choy types 8-12 inches apart and 24 inches between rows.

Daikon Radish (*Raphanus sativus*, var. longipinnatus, also called Chinese radish): This root crop is very closely related to the common radish. The main planting times are spring and fall, but some varieties can be planted almost year-round. Bolting (premature seedstalk) can

be a problem. Plant the seeds ¾ inch deep in April for a spring crop or in July for a fall crop. Plant spacing should be 4-6 inches between plants and 3 feet between rows. To compensate for large root size, plant daikon radishes in high raised beds that are amended with organic matter, such as compost. At each cultivation, work the soil higher and higher around the root as it grows. Most daikon radishes reach their useable size in 60-70 days.

Cucurbit Vegetables

Includes bittermelon, edible luffa gourd, winter melon.

Bittermelon (*Mormodica charantia*): This vegetable is a native of India. Like cucumbers and squashes, bittermelon is a member of the Cucurbit family. It is a warm-season vegetable. It is usually grown on a trellis system and its fruit is about the size of a summer squash. The trellis should be 6-feet high and 4-6 feet apart. The seeds can be directly planted or grown as seedlings with spacing at 1.5-2 feet between plants and 3-5 feet between rows. Bittermelon is harvested green before there is any color change. Bright orange fruits are saved for seed collection.

Edible Luffa: The edible luffas come in two forms: smooth and angled.

Smooth luffa, *Luffa cylindrica*, originated in India and was later taken to China. It is mainly grown for the young squash-like fruits. Some of the luffa cultivars are Smooth Boy, Smooth Beauty, and Southern Winner. If left to mature on the plant, smooth luffa gourd produces the familiar "Luffa sponge" found in stores. Luffa plants are warm-season vegetables and need to be trellised.

Angled Luffa, *Luffa actuangula*, is very similar to the smooth luffa. Luffa gourds are trained on trellises to encourage straighter fruits, which can become more curved if allowed to grow on the ground. Just like smooth luffa, the angled luffa is a warm-season annual vegetable. The quality of this squash as a sponge gourd is not as desirable; however, in stir fries and other foods it excels. Some of the angled luffa cultivars are Hybrid Green Glory, Hybrid Asian Pride, Lucky Boy, and Summer Long.

Legumes

Includes asparagus (yardlong) bean, edible snap sugar peas, snow peas.

Asparagus (Yardlong) Bean (Chinese Long Bean, *Vigna sesquipedalis*): This long, trailing vine should be grown on trellises. This plant is more closely related to black-eyed pea than to the common green snap bean. Dark and light green varieties are available as well as a red type. The darker varieties are generally preferred. It is a warm-season vegetable. Yardlong beans are cut into 2-inch pieces and added to various stir fries. The paler green is sweeter and more tender than the dark green.

Sugar Snap Pea and Snow Pea (*Pisum sativum*): These cool-season vegetables should be sowed in April for a spring crop or sowed in July for a fall crop. Plants deteriorate quickly in the heat of summer. The plants of sugar snap pea and snow pea grow similarly to bush beans. It is often helpful to grow them on trellises to facilitate picking; however, if grown for the tender shoot tips, they are usually left untrellised.

Fruiting Vegetables

Includes Oriental eggplant.

Oriental Eggplants (*Solanum melongena*): This crop is native to tropical Asia and are very popular in Japan, China, India, Thailand, and the Philippines. Many varieties are available. They can be light or dark purple, brown, or green in skin color; and round and slender in shape.

Eggplants require full sun and well-drained soil. Eggplants must have warm soil to grow well and they take a long time to reach maturity. Hence, it is a good idea to start seedlings in a greenhouse and set the transplants in the field after the danger of frost is over. Transplant eggplants 18-24 inches apart in rows 30-36 inches apart between rows. Eggplants grow best in hot weather. Water the plants during dry spells. Harvest usually begins in mid- to late summer, about 70-90 days after sowing seeds. Harvest eggplants when the fruit reaches the right size and when skin is glossy and firm. Fruit sizes vary depend on the variety.

Resources

"Ethnic Vegetables: Asian," University of Kentucky Extension, www.uky.edu/Ag/NewCrops/introsheets/asian.pdf.

"Asian Vegetables: Selected Fruit and Leafy Types," Purdue University Center for New Crops and Plants Products, www.hort.purdue.edu/newcrop/proceedings1996/v3-488.html.

"Asian Vegetables," Purdue University Center for New Crops and Plants Products, www.hort.purdue.edu/newcrop/proceedings1990/V1-387.html.

Speciality and Minor Crops Handbook, second edition, University of California Agriculture and Natural Resources publication 3346, available from ANRCatalog, anrcatalog.ucdavis.edu.

Manual of Minor Vegetables, University of Florida IFAS publication SP 40, available from IFAS Extension Bookstore, ifasbooks.ifas.ufl.edu.

Cole Crops and Brassica Leafy Greens

Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Mustard, and Turnip Greens

BROCCOLI Varieties	Maturity	Comments
Leprechaun	early	Large beads, slightly domed
Regal	early	Medium to small beads, firm domed heads, side shoots
Green Comet	early	Excellent center head and large side shoots
Emperor	early-mid	Few side shoots
Green Valiant	mid	Small beads, firm head
Premium Crop	mid	Large center heads, few side shoots
Goliath	mid	Large, tight heads
Gypsy	mid	Smooth, domed heads
Marathon	late	Domed
Triathlon	late	Excellent crown cut or bunching broccoli in Missouri
Arcadia	late	Small beads, very domed

BRUSSELS SPROUTS Varieties	Maturity	Comments
Prince Marvel	medium	Medium sprouts, large plants
Oliver	early	Large sprouts, short plants
Dasher	late	Medium sprouts
Jade Cross	early	

CABBAGE Varieties	Season	Head Size	Yellows Resistance	Remarks
Green				
Stone Head	very early	small	no	Solid head for an early type
Head Start	early	medium	no	Excellent field holding for an early type
Charmant	early	small	yes	Flattened round head. Tolerant to tipburn, black speck
Conquest	main	medium	yes	
Bronco	late	medium	yes	
Green Cup	main	medium-large	yes	High tolerance to black rot-tolerant to thrips, tipburn, heat, cold.
Blue Pak	main	medium-large	yes	Good tip burn tolerance, very thrips tolerant
Cheers	late	large	yes	
Rio Verde	late	large	yes	
Hinova	late		yes	For processing, flat, rounded heads, resistant to tipburn; tolerant to black rot, black speck; susceptible to thrips
Red				
Red Acre	main	small	no	A firm head, open pollinated
Regal Red	early	medium	no	Early for a red cabbage
Ruby Perfection	late	small	no	Deep red color, thrips tolerant

CAULIFLOWER Varieties	Season	Comments
Snow Crown-F1 Hybrid	early	Good and reliable for spring and early fall production
Fremont F1	2nd early	
Snowball Y improved op	main	Forming heads should be blanched
Andes op	main	Forming heads should be blanched
White Sails F1	main	Forming heads should be blanched
Self-Blanche op	late	No tying necessary if plants are fertilized properly
Silver Streak	late	For fall harvest
For trial only: Candid Charm (2nd early), Cashmere (early), Cumberland (main), Majestic (early)		

Spacing

Broccoli: Rows 3 feet apart. Plants 12 to 18 inches apart in row.

Brussels sprouts: Rows 3 feet apart. Plants 18 to 24 inches apart in row.

Cabbage for Market: Rows 2 to 3 feet apart. Plants 12 to 15 inches apart in row.

Cabbage for Kraut: Rows 3 feet apart. Plants 18 inches apart in row.

Cauliflower: Rows 3 feet apart. Plants 15 to 18 inches apart in row.

Collards: Rows 3 to 3.5 feet apart. Plants 18 to 24 inches apart in row. Seed 1 to 2 pounds per acre.

Kale: Rows 2 to 3 feet apart. Plants 8 to 16 inches apart in row. Seed 2 to 4 pounds per acre.

Mustard: Rows 1 to 1.5 feet apart. Plants 10 to 12 inches apart in row. Seed 3 to 5 pounds per acre.

Turnip greens: Rows 6 to 12 inches apart. Plants 1 to 4 inches apart in row.

Raised beds (6 inches high, 40 inches wide, with 2 rows 11 inches apart on beds) may be desirable under certain conditions.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.5.

Preplant

Cole crops (broccoli, cabbage, cauliflower, and Brussels sprouts)

N: 120 pounds per acre if soil organic matter less than 3 percent, and 80 pounds per acre if soil organic matter greater than 3 percent. **P_2O_5:** 25 to 200 pounds per acre. **K_2O:** 0 to 250 pounds per acre. Cole crops, particularly cauliflower, are responsive to B on low organic matter soils, sandy soils, or where the pH is greater than 7.0. If B is needed, apply 1 to 2 pounds B per acre broadcast. Soil test and/or perform plant analysis on the previous crop to be sure B is needed. High soil B can be detrimental to rotational crops such as sweet corn, peas, or beans.

Greens (collards, kale, and mustard)

N: 60 pounds per acre. **P_2O_5:** 0 to 150 pounds per acre. **K_2O:** 0 to 200 pounds per acre.

All crops

Adjust recommendations according to soil type, previous management, and soil test results for your state. For transplants, set each plant with 1 cup (8 ounces) of starter solution. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

Sidedress N

Cole Crops

60 pounds N per acre, two to three weeks after setting the transplants and when rapid growth has begun. Eliminate sidedressing if following soybeans. If leaching is likely on sandy soils, apply an additional 30 pounds N as a sidedress. Avoid excessive N fertilization with broccoli as it can cause too rapid growth and a hollow flower stalk.

Greens

30 pounds N per acre on soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop. For greens on soils with less than 3 percent organic matter and following those crops, apply 45 pounds N per acre. For greens following corn, small grains, or a vegetable crop, apply 60 pounds N per acre.

Harvesting

Broccoli: Harvesting is done by hand while the head is still compact and before the flowers open. The central heads should be dark blue or green and 4 to 6 inches across when mature. If harvesting too late or when the heads are over mature, woodiness in the stems will develop. Depending on your marketing requirements, the main head is cut with 8 to 10 inches of stem. Sometimes a second harvest of side shoots can be obtained. Broccoli for processing should be cut with less attached stem (6 to 7 inches) and with few or no leaves. Fresh market broccoli should be cut longer, with little trimming. Broccoli quality is based on the degree of compactness, leafiness, head trimness, damage, and freedom from insects and extraneous debris.

Cauliflower: When ready to harvest, the heads should be compact and clear white. The heads become discolored and develop an undesirable flavor when exposed to sunlight. The longest leaves are normally tied loosely together over the head to "blanch" and prevent the head from being exposed to the sun. The desirable harvest size is a diameter of approximately 6 inches. Delaying harvest usually will not result in obtaining larger heads. Instead, consider proper cultivar selection and plant spacing. Cauliflower should be hand-harvested and cut with 1 to 2 whorls of leaves to protect the head.

Disease Control

Alternaria Leaf Spot

Practice a 3-4 year crop rotation, and rotate to non-cruciferous crops.

Recommended Products

Bravo®, Echo®, Equus®, and **Initiate®** formulations are labeled at various rates. *Not for collard, kale, mustard, or turnip greens.* 7-day PHI.

Cabrio® at the following rates:

Turnip greens: 8-12 oz. per acre.

All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Endura 70WG® at 6-9 oz. per acre. *Not for turnip greens*. 14-day PHI for collard, kale, and mustard. 0-day PHI for all others.

RR **Fontelis®** at 14-30 fl. oz. per acre. 0-day PHI.

RR **Quadris®** at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Reason® at 8.2 fl. oz. per acre. 2-day PHI.

Ridomil Gold Bravo® at 1.5 lbs. per acre. *Not for collard, kale, mustard, or turnip greens*. 7-day PHI.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

RR **Switch®** at 11-14 oz. per acre. 7-day PHI.

Black Leg

Black leg is an important disease of broccoli, Brussels sprouts, cauliflower, and turnip. Since oilseed rape is particularly susceptible to black leg, avoid planting crucifer crops close to oilseed rape. Practice a 3-4 year crop rotation, and rotate to non-cruciferous crops. Plant disease-free seeds or transplants. Hot water seed treatment helps eliminate seedborne pathogens.

Recommended Products

Cabrio® at 12-16 oz. per acre. 0-day PHI

Rovral® at 2 pts. per acre for flowable (F) formulations, or at 1.3 lbs. per acre for dry formulations. *Broccoli only*. 0-day PHI.

Black Rot

Practice a 3-4 year crop rotation, and rotate to non-cruciferous crops. Plant disease-free seeds or transplants. Hot water seed treatment helps eliminate seedborne pathogens. Plant disease-resistant cabbage varieties — several varieties with partial resistance are available.

Recommended Products

Actigard® at 0.5-1 oz. per acre. *Suppression only*. Do not apply to stressed plants. 7-day PHI.

Fixed copper formulations at various rates. Read labels carefully to make sure your crop is included. Copper applications may slow the spread of black rot.

Club Root

Plant only disease-free transplants. Club root may be brought in with diseased transplants.

Rotate crops 5 years or more with a non-cruciferous crop between plantings. Avoid poorly drained soils with a history of club root. Serious losses can be avoided by raising the pH to 7.2-7.3.

Recommended Products

Terraclor 75WP® flowable fungicide. Rate depends on application method. *Not for turnip.* Terraclor® may be used in a transplant solution or in a band or broadcast application at planting.

Downy Mildew

Practice a 2 year crop rotation. Rotating to non-cruciferous crops may reduce pathogen populations and increase fungicide efficacy. Plant disease-resistant broccoli varieties — several varieties with resistance are available.

Recommended Products

Actigard® at 0.5-1 oz. per acre. Do not apply to stressed plants. 7-day PHI.

BP **Agri-Fos 400®** at 1.25-2.5 qts. per acre. *Not for turnip greens*. 0-day PHI.

Aliette® at 2-5 lbs. per acre. *Not for turnip*. 3-day PHI.

Bravo®, **Echo®**, and **Equus®** formulations are labeled at various rates. *Not for use on collard, kale, mustard, or turnip greens*. 7-day PHI.

Cabrio® at the following rates:

Turnip greens: 8-12 oz. per acre.

All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Forum® at 6 fl. oz. per acre. 0-day PHI.

BP **Phostrol®** at 2.5-5 pts. per acre. *Not for turnip greens*.

Presidio® at 3-4 oz. per acre. *Not for collard, mustard, kale, or turnip.* 2-day PHI.

Prophyt® at 2-4 pts. per acre. *Not for turnip greens*. 0-day PHI.

RR **Quadris®** at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. 2-day PHI.

RR **Revus 2.09SC®** at 8 fl. oz. per acre. *Not for turnip greens*. 1-day PHI.

Ridomil Gold Bravo SC ® at 1.5 pts. per acre. 0-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Zampro® at 14 fl. oz. per acre. *Not for turnips*. 0-day PHI.

Fusarium Yellows

Plant yellows-resistant varieties. Disease may be seedborne.

Powdery Mildew

Resistant cultivars exist for Brussels sprout and cabbage.

Recommended Products

Cabrio® at the following rates:

Turnip greens: 8-12 oz. per acre.

All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Endura 70WG® at 6-9 oz. per acre. *Not for turnip greens*. *Suppression only*. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others.

RR **Fontelis**® at 14-30 fl. oz. per acre. 0-day PHI.

Microthiol Disperss® at 3-10 lbs. per acre. 0-day PHI.

Rhizoctonia Diseases

Clean and sanitize transplant trays, benches, etc.

Recommended Products

Bottom Rot

Endura 70WG® at 6-9 oz. per acre. *Not for turnip greens*. *Suppression only*. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others.

Rhizoctonia Blight

Cabrio® at the following rates:

Turnip greens: 8-12 oz. per acre.

All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Sclerotinia Stem Rot

Recommended Products

Cabrio EG® at 12-16 oz. per acre. *Collards, kale, and mustard only.* 3-day PHI.

Endura 70WG® at 6-9 oz. per acre. *Not for turnip greens*. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others. No more than 2 applications per season.

RR **Fontelis**® at 16-30 fl. oz. per acre. 0-day PHI.

White Rust

Use crop rotations of 2-3 years, practice sanitation, use pathogen-free seed, and use resistant varieties when possible.

Recommended Products

Cabrio EG® at 12-16 fl. oz. per acre. 0-day PHI.

Reason® at 8.2 fl. oz. per acre. 2-day PHI.

Wirestem

Terraclor® flowable or granular. Rate depends on application method. *Not for turnip*. May be used in a transplant solution or in a band or broadcast application at planting. Raise seedlings in seedbeds that are disinfected by steam or chemical fumigants.

Weed Control

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Application Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2-4 pts. per acre. *Not for turnip greens*. Include 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gallons of spray solution. Apply before seeding or transplanting, or after seeding but before crop emergence. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae/gal. (4 lbs. isopropylamine salt/gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae/gal. (5 lbs. potassium salt/gal.) at 0.66-3.3 qts. per acre. *Not for turnip greens*. Broadcast before seeding or transplanting, after seeding but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Burndown or Directed/Shielded Application Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at the following rates:

Cabbage transplants: up to 1.3 pts. per acre.

Broccoli, Brussels sprouts, and cauliflower: 0.67 pt. per acre.

Not for collards, kale, mustard greens, or turnip greens. Apply before seeding or transplanting or after seeding before crop emerges. 45-day PHI for cabbage.

Devrinol 50DF® at 2 lbs. per acre. *Not for collards, kale, mustard greens, or turnip greens*. Apply and incorporate 1-2 inches before seeding or transplanting or apply after seeding and irrigate to wet soil 2-4 inches deep. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application.

Dual Magnum® in *Indiana and Ohio only* at the following rates:

Broccoli raab, Chinese cabbage (bok choy), collards, kale, mizuna, mustard greens, mustard spinach, rape greens, and turnip greens: 0.67-1.3 pts. per acre. Apply after seeding before weeds or crop emerge, or apply broadcast after crops have 1-2 true leaves. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 30-day PHI.

Cabbage transplants: 0.5-1.3 pts. per acre. Apply before transplanting and do not incorporate, or apply within 48 hours after transplanting. Reduce risk of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 60-day PHI.

Trifluralin products at 0.5-0.75 lbs. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. *Not for turnip greens*. Use low rate on soils with less than 2% organic matter. Apply before seeding or transplanting and incorporate 2-3 inches immediately. Not effective on muck or high organic matter soils. Delayed emergence or stunting may occur when soil is cool.

Preemergence Broadleaves

Recommended Products

Spartan 4F® at 2.25-12 fl. oz. per acre. *Transplanted cabbage for processing only*. *Not for broccoli, Brussels sprouts, fresh market cabbage, cauliflower, collards, kale, mustard or turnip greens*. Apply preemergence before transplanting as a broadcast or banded spray or band to row middles within 72 hours after transplanting. May be incorporated no deeper than 2 inches before transplanting. Do not use on soils classified as sand, with less than 1% organic matter. Controls pigweeds.

Spartan Charge® at 2.9-15.2 fl. oz. per acre. *Transplanted cabbage only*. *Not for broccoli, cauliflower, Brussels sprouts, collards, kale, mustard greens, or turnip greens*. Apply before transplanting, or band between rows within 72 hours after transplanting. May be incorporated no deeper than 2 inches before transplanting. Do not use on sandy soils with less than 1% organic matter. Has not been tested on all varieties. Refer to label for additional precautions. Maximum 15.2 fl. oz. per acre.

Goal 2XL® at 1-2 pts. per acre. *Not for direct-seeded crops*. *Not for Brussels sprouts, collards, kale, mustard greens, or turnip greens*. Use lower rate on coarse-textured soils. Apply after preparing soil but before transplanting. Transplant within 7 days of application.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable®** at 6-14 pts. per acre. Apply at seeding or transplanting. May be incorporated. May be applied over top of transplants.

Prefar 4E® at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 inches or apply after seeding before crop emerges and irrigate within 24 hours.

Postemergence

Recommended Products

Glyphosate products. See details above under Burndown or Directed/Shielded Application.

Aim EC®. See details above under Burndown or Directed/Shielded Application.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season.

Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. 14-day PHI for greens. 30-day PHI for broccoli, Brussels sprouts, cauliflower, cabbage, and kohlrabi.

Poast 1.5E® at 1-1.5 pts. per acre, plus 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 2.5 pts. per acre per season for turnip greens, or 3 pts. per acre per season for other crops. 14-day PHI for turnip greens. 30-day PHI for all others.

Herbicides for Cole Crops and Leafy Greens[1]

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop						Timing Relative to Weeds		Weed Groups Controlled			Crops						
		Before seeding	After seeding before emergence	Before transplanting	Post emergence — between rows only	Postemergence	Incorporated	Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Broccoli	Brussels sprouts	Cabbage	Cauliflower	Brassica greens	Turnip greens
Aim EC® (12h/-)	carfentrazone				X				X			X	X	X	X	X	X	X
Command 3ME® (12h/45d)	clomazone	X	X	X				X		X	X	X	X	X	X	X		
Dacthal® (12h/-)	DCPA	X	X	X		X		X		X			X	X	X	X	X	X
Devrinol 50DF® (12h/-)	napropamide	X	X	X			Yes	X	X	X	X	X	X	X	X	X		
Dual Magnum® (24h/21d)	s-metolachlor		X			X		X		X	X				X		X	X
Goal 2XL® (12h/-)	oxyfluorfen			X				X			X	X	X		X	X		
Gramoxone Inteon 2L® (12h to 24h/-)	paraquat	X	X	X					X	X	X	X	X	X	X	X	X	
Poast® (12h/14-30d)	sethoxydim	X	X	X		X			X	X			X	X	X	X	X	X
Prefar 4E® (12h/-)	bensulide	X	X	X				X		X			X	X	X	X	X	X
Roundup®, others (12h/14d)	glyphosate	X	X	X	X				X	X	X	X	X	X	X	X	X	
Select Max®, others (12h/14-30d)	clethodim	X	X	X		X			X	X			X	X	X	X	X	X
Spartan DF® (12h/1d)	sulfentrazone			X	X			X			X				X			
Spartan Charge® (12h/-)	sulfentrazone plus carfentrazone			X	X			X	X		X				X			
Treflan®, others (12h/-)	trifluralin	X		X			Yes	X		X	X		X	X	X	X	X	

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.

Insect Control

Aphids, Leafminers

Conserve natural enemies.

Limit the use of insecticides to conserve predators and parasites.

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. *Aphids only*. Do not exceed 11 oz. per acre pre season. 0-day PHI for broccoli, Brussels sprouts, cabbage and cauliflower. 7-day PHI for leafy greens.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

RR **Assail 30SG**® at 2-4 oz. per acre. *Aphids only*. Do not exceed 20 oz. per acre per season. 7-day PHI.

Belay 2.13SC® at 3-4 fl. oz. per acre. *Aphids only*. 21-day PHI.

Beleaf® at 2-2.8 oz. per acre. *Aphids only*. 0-day PHI.

Closer 2SC® at 1.5-2 fl. oz. per acre. 3-day PHI.

Dimethoate 400® or **Dimethoate 4E**® at 0.5-1 pt. per acre, or **Dimethoate 2.67EC**® at 0.75-1.5 pts. per acre. 7-day PHI for broccoli and cauliflower. 10-day PHI for Brussels sprouts. 14-day PHI for kale and mustard.

OMRI RR **Entrust**® at 1.25-3 oz. per acre. *Leafminers only*. Do not exceed 9 oz. per acre per season. 1-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per crop per season. 7-day PHI.

RR **Movento**® at 4-5 fl. oz. per acre. 1-day PHI.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

Orthene 97® at 0.5-1.0 lb. per acre. *Brussels sprouts and cauliflower only*. Do not exceed 2 1/8 lbs. per acre per season. 14-day PHI. *RUP*.

RR **Platinum**® at 5-11 fl. oz. per acre. 30-day PHI.

RR **Radiant SC**® at 6-10 fl. oz. per acre. *Leafminers only*. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. *Leafminers only*. Do not exceed 24 fl. oz. per acre per season. 7-day PHI.

Trigard® at 2.66 oz. per acre. *Leafminers only*. Do not exceed 6 applications per season. 7-day PHI.

Caterpillars (Imported Cabbageworms, Cabbage Loopers, Diamondback Moth Larvae, Cross-Striped Cabbageworms)

Recommended Products

Ambush 25W® at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Do not exceed 3.2 lbs. per acre per season to broccoli, Brussels sprouts, cauliflower, and collards.. Do not exceed 1 lb. a.i. per acre per season for cabbage. 1-day PHI. *RUP.*

Asana XL® at 2.9-9.6 fl. oz. per acre. *Cole crops and collards only. Cole crops:* Do not exceed 76.8 fl. oz. per acre per season. 3-day PHI. *Collards:* Do not exceed 38.4 fl. oz. per acre per season. 7-day PHI. *RUP.*

RR **Avaunt 30WDG**® at 2.5-3.5 oz. per acre. Do not exceed 14 oz. per acre per season. 3-day PHI.

BP Several ***Bacillus thuringiensis*** products (Agree®, Biobit®, Dipel®, Javelin®, Lepinox®, Xentari®) are available. Follow label directions. Begin applications when worms are small. Using Bt products will help conserve beneficial insects. 0-day PHI.

Baythroid® at 1.6-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RUP.*

Brigade 2EC® at 2.1-6.4 fl. oz. per acre (do not exceed 1 qt. per acre per season), or **Brigade WSB**® at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. *RUP.*

RR **Confirm 2F**® at 6.0-8.0 fl. oz. per acre. Do not exceed 56 fl. oz. per season. 7-day PHI.

RR **Coragen**® at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 3-day PHI.

OMRI RR **Entrust**® at 1.0-2.0 oz. per acre. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Exirel® **at the following rates:**

Cabbage loopers: 10-17 fl. oz. per acre.

Others: 7-13.5 fl. oz. per acre.

1-day PHI.

RR **Intrepid**® at 4-10 fl. oz. per acre. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

OMRI May be acceptable for use in certified organic production. Check with your certifier before use.

Lannate SP® at 0.25-1 lb. per acre. Add wetting agent. *Broccoli:* Do not exceed 7 lbs. per acre per season. Brussels sprouts and collards: Do not exceed 6 lbs. per acre per season. *Cabbage and cauliflower:* Do not exceed 8 lbs. a.i. per acre per season. *Kale and mustard:* Do not exceed 4 lbs. . 1-day PHI for cabbage. 3-day PHI for broccoli, Brussels sprouts, and cauliflower. 10-day PHI for collards, kale, and mustard. *RUP*.

Larvin 3.2® at 16-40 fl. oz. per acre. *Broccoli, cabbage, and cauliflower only.* Do not exceed 160 fl. oz. per acre per season. 7-day PHI. *RUP.*

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. *RUP.*

Orthene 97® at 1 lb. per acre. *Brussels sprouts and cauliflower only.* Do not exceed 2 lbs. per acre per season. 14-day PHI.

Pounce 25WP® at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Do not exceed 0.8 lb. a.i. per acre per season for broccoli. Do not exceed 1.6 lbs. per acre per season for Brussels sprouts, cabbage, cauliflower, and collards. 1-day PHI. *RUP.*

Proclaim® at 2.4-4.8 oz. per acre. Do not exceed 28.8 oz. per acre per season. Allow at least 7 days between applications. 7-day PHI for brassica head and stem vegetables. 14-day PHI for brassica leaf vegetables. *RUP.*

RR **Radiant SC®** at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 7-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 3-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for collards, kale, and mustard.

Synapse 24WG® at 3-5 oz. per acre. 1-day PHI.

Warrior II® at 0.96-1.92 fl. oz. per acre. *Cole crops only.* Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. *RUP.*

Flea Beetles

Recommended Products

FarMore FI400® commercial seed treatment for leafy Brassicas.

RR **Actara®** at 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 7-day PHI for leafy greens.

Ambush 25W® at 3.2-12.8 oz. per acre. Do not exceed 3.2 lbs. per acre per season for broccoli, Brussels sprouts, cauliflower, and collards. Do not exceed 4 lbs. per acre per season for cabbage. 1-day PHI. *RUP.*

Asana XL® at 5.8-9.6 fl. oz. per acre. *Cole crops and collards only*. *Cole crops*: Do not exceed 76.8 fl. oz. per acre per season. 3-day PHI. *Collards*: Do not exceed 38.4 fl. oz. per acre per season. 7-day PHI. *RUP*.

Baythroid® at 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre (do not exceed 1 qt. per acre per season), or **Brigade WSB®** at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. *RUP*.

Kryocide® at 8-16 lbs. per acre. Do not exceed 96 lbs. per acre per season. 7-day PHI for broccoli, Brussels sprouts, and cauliflower. 14-day PHI for cabbage and collards.

Larvin 3.2® at 16-32 fl. oz. per acre. *Broccoli, cabbage, and cauliflower only*. Do not exceed 160 fl. oz. per acre per season. 7-day PHI. *RUP*.

Caterpillar Thresholds

Crop	Stage	% Infested	
		Diamondback Moth Larvae	Imported Cabbageworm & Cabbage Looper
Cabbage — Fresh	seed bed	not applicable	not applicable
	transplant to cupping	50% with ≥ 5 larvae/plant	30%
	cupping to early head	50% with ≥ 5 larvae/plant	20%
	early head to harvest	10% with ≥ 1 larva/plant	10%
Broccoli, Cauliflower	seedbed	10%	10%
	transplant to first curl	40%	20%
	first curd to harvest	10%	10%

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. *RUP*.

Pounce 25WP® at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Do not exceed 3.2 lbs. per acre per season for broccoli. Do not exceed 1.6 lbs. per acre per season for Brussels sprouts, cabbage, cauliflower, and collards. 1-day PHI. *RUP*.

Prokil Cryolite 50D® at 15-30.5 lbs. per acre. Do not exceed 184 lbs. per acre per season. 7-day PHI for broccoli, Brussels sprouts, and cauliflower. 14-day PHI for cabbage and collards.

Sevin XLR PLUS® at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per crop. 3-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for collards, kale, and mustard.

Warrior II® at 1.28-1.92 fl. oz. per acre. *Cole crops only*. Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. *RUP*.

Harlequin Bug and Other Stink Bugs

Recommended Products

Azera ® at the following rates:

Harlequin bug nymphs: 2 fl. oz. per acre.

Adult harlequin bug and other stink bugs: 48 fl. oz. per acre. Use higher rates (48 fl. oz. per acre) when pest pressure is extreme or plant canopy is dense.

Do not exceed 10 applications per season. Do not reapply within 3 days except under extreme pest pressure. 0-day PHI.

Baythroid® at 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre (do not exceed 1 qt. per acre per season), or **Brigade WSB®** at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. *RUP*.

Malathion 5EC® at 1.5 pts. per acre, or **Malathion 57EC®** at 1 pt. per 100 gallons of water per acre. *Harlequin bug on collards only*. PHI varies by crop — check the label.

Mustang MAX® at 3.2-4 oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. *RUP*.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 oz. or 2 applications per acre per season. 7-day PHI.

Sevin XLR PLUS® at the following rates:

Harlequin bug: 0.5-1 qt. per acre.

Other stink bugs: 1-2 qts. per acre.

Do not exceed 6 qts. per acre per season. 3-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. *Cole crops only*. Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. *RUP*.

Root Maggots

Cabbage maggot injury is usually more severe when fields have decaying organic matter present, such as plowed down cover crop, or when cool, wet conditions prevail.

Recommended Products

For use in transplanting water, mix any one of these products in 50 gallons of water. Refer to the comments for each product or product labels regarding drench applications. The transplant mixture application (insecticide plus water) will require about 200-300 gallons of water per acre, based on the number of plants set per acre.

Capture LFR® at 0.2-0.39 fl. oz. per 1,000 linear ft. of row. See label. *RUP*.

Diazinon AG500® at 2-3 qts. per acre, or **Diazinon 50W®** at 4-6 lbs. in 50 gals. of water (for drench application). Water treatments may reduce stands due to plant stress at time of transplanting. Make drench application at the rate of 0.5-1 cup per plant, either by hand or tractor-mounted sprayer with drop nozzles to direct spray to base of plants. In some areas, cabbage maggots are exhibiting resistance to diazinon, resulting in control failures. 4-day PHI. *RUP*.

Lorsban® products at the following rates:

Cauliflower: Lorsban 4EC® at 1.6-2.4 fl. oz. per 1,000 linear ft. of row, or Lorsban 75WG® at 1.1-1.6 fl. oz. per 1,000 linear ft. of row.

Broccoli, Brussels sprouts, cabbage, collards, and kale: Lorsban 4EC® at 1.6-2.75 fl. oz. per 1,000 linear ft. of row, or Lorsban 75WG® at 1.1-1.8 fl. oz. per 1,000 linear ft. of row.

Apply as a water-based spray directed at the base of plants immediately after setting in field. Use a minimum of 40 gallons of total spray per acre. Do not apply as a foliage application. Do not exceed one application per acre per season. 30-day PHI. *RUP*.

Thrips

Some cabbage varieties are resistant to thrips, such as Bantly, Bravo, Brutus, King Cole, Little Rock, Manrico, Rio Granda, Rio Verde, Ruby Perfection, Starski, Stonar, SuperKraut, Titanic 90, Zerlina, and others.

Recommended Products

RR **Actara**® at 3-5.5 oz. per acre. Do not exceed 11 oz. per acre pre season. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 7-day PHI for leafy greens.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Ambush 25W® at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Do not exceed 0.8 lb. a.i. per acre per season for broccoli, Brussels sprouts, cauliflower, and collards. Do not exceed 1 lb. a.i. per acre per season for cabbage. 1-day PHI. *RUP*.

RR **Assail 30SG**® at 4 oz. per acre. Do not exceed 0.375 lb. a.i. per acre per season. 7-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16 oz. per acre. Do not exceed 0.5 lb. a.i. per acre per season. 7-day PHI. *RUP*.

RR **Entrust**® at 2-3 oz. per acre. Do not exceed 9 oz. per acre per season. 1-day PHI.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

Mustang MAX® at 3.2-4.0 fl. oz. per acre. Do not exceed 0.15 lb. a.i. per acre per season. Allow 7 days between applications. 1-day PHI. *RUP*.

Pounce 25WP® at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Do not exceed 0.8 lb. a.i. per acre per season for broccoli. Do not exceed 0.4 lb. a.i. per acre per season for Brussels sprouts, cabbage, cauliflower, and collards. 1-day PHI. *RUP*.

RR **Radiant SC**® at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. *Cole crops only*. Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. *RUP*.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Avoid using broad-spectrum insecticides early in the season to preserve predators of pests like this diamondback moth larvae.

Cucurbit Crops — Squash and Pumpkin

Varieties		
Summer Squash	Golden Zucchini	Goldfinger, Gold Rush, Golden Delight, Golden Glory
	Middle Eastern	Lita, Bonita
	Yellow Crookneck	Dixie, Prelude 2
	Yellow Straightneck	Lemondrop L, Multipick, General Patton, Monet, Liberator III, Fortune, Lazor, Enterprsie, Goldprize
	Zucchini	Revenue, Dividend, Spineless Beauty, Jaguar, Puma, Independence III, Lynx, Spineless King, Spineless Perfection
Winter Squash	Acorn	Table Ace, Seneca Autumn Queen, Taybelle, Table Star (PM*), Mesa Queen
	Butternut	Butternut Supreme, Zenith, Waltham, Early Butternut, Butterboy
	Buttercup	Autumn Cup, BonBon, Buttercup, Burgess, Sweet Mama (Kabocha hybrid)
	Hubbard	Blue Hubbard, Red Kuri (small, red fruits)
	Spaghetti	Vegetable Spaghetti, Tivoli
	Other	Bush Delicata, Sugar Loaf, Carnival, Sweet Dumpling
Pumpkin	Miniature	Apprentice (PM*), Baby Boo (white), Crunchkin (mottled, attractive orange-yellow skin), Gold Dust (PM*), Gold Speck (PM*), Jack Be Little, Lil' Ironsides, Lil' Orangemon, Lil' Pump-ke-mon, Mini-Jack, Munchkin, Sweetie Pie, Wee-B Little
	For trial	Little Giant, Mischief
	Small size	Baby Bear, Cannonball (PM*), Field Trip (PM*), Gargoyle (PM*), Hybrid Pam, Iron Man (PM*), Mystic Plus (PM*), Orange Smoothie (smooth skin), Oz, Pik-A-Pie, Prankster (PM*), Small Sugar, Spookie, Spooktacular, Touch of Autumn (PM)
	Medium size	Gold Fever, Gold Standard, Magician (PM*), Sorcerer, Tom Fox, Wizard
	For trial	New Rocket
	Medium-large and large size	18 Karat Gold (PM*), 20 Karat Gold (PM*), Aladdin (PM*), Appalachian, Captain Jack, (30+ lb), Diablo, Dependable, Gladiator (PM*), Gold Challenger, Gold Medallion, Harvest Time, Howden Biggie, Magic Lantern (PM*), Magic Wand (PM*), Merlin (PM*), Phat Jack, Phatso Jr, Phatso II, Pro Gold 510, Solid Gold
	For trial	Autumn King, Big Rock, Camaro (PM*), Expert (PM*), King Midas, Mr. Wrinkles, Mustang PMR (PM*), Phatso III (PM*), Spartan (PM*), Super Herc (PM*), Trojan, Warlock (PM*)
	Very large size	Atlantic Giant, Big Max, Big Moon, Prize Winner
	Specialty types	Buckskin, Fairytale, Jarradale, Rouge Vif D'Etampes (Cinderella), Superfreaks: Goosebumps (Lots of bumps, smaller and more round than Knucklehead), Superfreaks: Knucklehead (Lots of bumps), **White:** Moonshine
	Hull-less/naked seed	Trick-or-Treat, Triple Treat, Snack Jack

*PM=partially resistant to powdery mildew.

Cantaloupe or Muskmelon?

Both cantaloupe and muskmelon are acceptable names for fruit from the vines known to scientists as *Cucumis melo* subsp. *melo* var. *cantalupensis*. In this guide, we use cantaloupe to agree with USDA standards, which use this term.

Spacing and Seeding

Bush Types: Rows 4-6 feet apart. Plant 18-24 inches apart in row. Seed: 4-6 pounds per acre.

Vining Types: Rows 6-8 feet apart. Plant 2-5 feet apart in row. Seed: 2-3 pounds per acre.

Fertilizing

Lime: To maintain a soil pH of 6.0-6.8.

Preplant: N: 50 pounds per acre; P_2O_5: 0-150 pounds per acre; K_2O: 0-200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For summer squash transplants, a starter solution at a rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

Sidedress N: For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, no N is needed. For soils with less than 3 percent organic matter with the same rotation or a rotation of corn, rye, oats, wheat, or a vegetable crop, apply 30-40 pounds N per acre when the vines begin to run. For sandy soils, the preplant N application can be replaced by an early sidedressing of 40 pounds N per acre when the plants show the first set of true leaves. Apply the second sidedressing of 45 pounds N per acre at onset of rapid vining.

For crops grown from transplants on plastic mulch, N losses from leaching are greatly reduced. For this culture system, apply 50 pounds N per acre broadcast preplant over the row just before laying the plastic. If sidedress N is recommended (see above), apply up to 30 pounds N per acre on either side of the plastic at vining when the plant roots have reached the edge of the plastic. If you are using trickle irrigation, apply the 50 pounds N per acre preplant, and apply 0.5-1 pound N per acre daily, or 3-6 pounds N weekly through the trickle system if additional N is needed.

Disease Control for Squash and Pumpkin

Angular Leaf Spot

Angular leaf spot may be transmitted via seed. Lesions on leaves and fruit of pumpkin and squash are similar in appearance to those of bacterial leaf and fruit spot. Angular leaf spot is a cool weather disease, normally restricted to the spring or early summer.

Recommended Products

Several **copper-based** bactericides are effective against angular leaf spot.

Dithane® and **Manzate**® may help manage angular leaf spot when used with fixed copper products.

Bacterial Fruit Blotch

Bacterial fruit blotch is much more likely to occur on watermelon than on squash or pumpkin. See the bacterial fruit blotch section in Disease Control for Cantaloupe, Cucumber, and Watermelon, page 105.

Bacterial Leaf and Fruit Spot

Bacterial fruit spot occurs primarily on pumpkin and squash. Symptoms on leaves may occur throughout the season. However, only lesions on fruit are of economic importance.

Disease organism may survive on crop residue and be transmitted on seed. All squash and pumpkin varieties appear to be susceptible. Symptoms may be similar to angular leaf spot.

Winter/Off-season: Rotate crops at least 3 years and practice fall tillage. May be seedborne. Avoid problem fields.

Planting: Treat with fixed copper compounds if symptoms are present.

Vine Touch: If disease threatens, apply fixed copper sprays when fruit is softball-sized. Tank mix copper and mancozeb products. Continue applications until fruit set is complete.

Harvest: Do not save seed from affected fields. Identify fruit problems.

Recommended Products

Copper applications at 10-day intervals (for three or four applications) beginning when fruit are approximately 4 inches in diameter.

Dithane® and **Manzate**® may help manage bacterial leaf spot when used with fixed copper products.

Bacterial Wilt

This disease affects pumpkins and squash only when striped and spotted beetles feed on the plants before the 5 true leaf stage. Disease control depends on control of striped and spotted cucumber beetles. Regularly scout fields for beetles.

Winter/Off-season: The disease is unaffected by crop rotation.

Planting: Apply systemic insecticides such as Admire® or Platinum® (see insect section). Apply contact insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply insecticides only when beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

Damping-off

Practice good greenhouse sanitation. The best way to prevent damping-off of seedlings in the greenhouse is to keep the greenhouse area clean. See section on Transplant Production, page 20.

Plant in warm field soils. The fungi responsible for damping off in field soils cause more loss when the seedling is slow to emerge.

Recommended Products

Previcur Flex®. See label for greenhouse uses and details about managing damping-off caused by Pythium species.

Ridomil Gold SL ®at 1-2 pts. per acre. For use on damping-off caused by Pythium species.

Downy Mildew

This fungal disease does not survive in the Midwest and therefore is spread by wind. Downy mildew may not occur in the Midwest until August or September and in some years, does not occur in the Midwest at all.

Strains of the downy mildew fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin fungicides (such as Cabrio®, Flint®, Merivon®, Pristine®, Quadris®, Reason®, Satori®) and fungicides with the active ingredient mefenoxam (such as Ridomil®) are particularly susceptible to resistance. See Fungicide Resistance Management (page 72) for more information.

Winter/Off-season: The disease is unaffected by crop rotation.

Planting: Begin scouting in July. Follow disease progress in the Purdue Extension *Vegetable Crops Hotline* bulletin or at cdm.ipmpipe.org. Apply specialized systemic downy mildew fungicides only if disease is observed in the area.

Recommended Products

Aliette® at 2-5 lbs. per acre. Do not tank mix with copper products. 0-day PHI.

Bravo®, **Echo**®, **Equus**® are labeled for use at various rates. 0-day PHI.

Cabrio® at 8-12 oz. per acre. 0-day PHI.

Curzate 60DF® at 3.2-5.0 oz. per acre. 3-day PHI.

RR **Flint**® at 4 oz. per acre. Limit 16 oz. per acre per season. 0-day PHI.

Forum 4.18SC® at 6 fl. oz. per acre. 0-day PHI.

Mancozeb products (including Dithane® or Manzate®) are labeled at various rates. *Some mancozeb formulations may not be labeled for pumpkin.* 5-day PHI.

Merivon® at 5.5 fl. oz. per acre. *Suppression only.* Must have supplemental label. 0-day PHI.

Several **phosphite** or **phosphorous acid** products are labeled at various rates (including Agri-Fos®, Phostrol®, and Prophyt®). Label includes several different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank mixing. 0-day PHI.

Presidio® at 3-4 fl. oz. per acre. 2-day PHI.

Previcur Flex® at 1.2 pts. per acre. 2-day PHI.

Pristine 38WG® at 12.5-18.5 oz. per acre. 0-day PHI.

RR **Quadris 2.08**® at 11-15.5 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

Reason 500 SC® at 5.5 fl. oz. per acre. 14-day PHI.

RR **Ranman**® at 2.1-2.75 lbs. per acre. 0-day PHI.

RR **Revus 2.09SC**® at 8 fl. oz. per acre. 0-day PHI.

Ridomil Gold Bravo® at 2 lbs. per acre. Alternate with protective fungicide. 0-day PHI.

Satori® at 11-15.5 oz. per acre. 1-day PHI.

Tanos 50DF® at 8 oz. per acre. See comments for Tanos® under Alternaria Leaf Blight. 3-day PHI.

Zampro® at 14 fl. oz. per acre 0-day PHI.

Fusarium Fruit Rot

Pumpkin fruit are more likely than other cucurbits to be affected by Fusarium fruit rot. There are no symptoms on foliage. No resistant varieties are available. Fruit with Fusarium fruit rot are often observed from fields where other disease or cultural problems are present.

Winter/Off-season: Rotate with noncucurbit crops at least 4 years. Pumpkins grown in cover crops may help lessen the impact of this disease. Avoid fields with a history of disease. May be seedborne.

Planting: Manage foliar diseases for better fruit health. Avoid other fruit diseases, such as bacterial fruit spot and Phytophthora blight.

Harvest: Identify fruit problems.

Gummy Stem Blight/Black Rot

Gummy stem blight may occur on cucurbits from transplant through harvest. The leaves and stems may be affected. Occasionally, fruit are affected, which is known as black rot. The black rot phase of the disease is more common in pumpkins than the gummy stem blight phase.

Strains of the gummy stem blight fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin fungicides in Group 11 (such as Cabrio®, Flint®, Merivon®, Pristine®, Quadris®, Satori®) and fungicides with the active ingredient boscalid Group 7 (such as Fontelis® and Pristine®) are particularly susceptible to resistance. See Fungicide Resistance Management (page 72) for more information. Tank mix these products with products that have a different mode of action in situations where resistance may be a factor.

Winter/Off-season: Rotate crops at least 3 years and practice fall tillage. May be seedborne.

Greenhouse: Scout for disease. Apply fungicide labeled for greenhouse if necessary.

Planting: Avoid planting diseased seedlings in the field.

Vine Touch: Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, www.the-education-store.com.

Harvest: Identify fruit problems.

Recommended Products

Bravo®, **Echo®**, **Equus®**, and **Initiate®** are labeled for use at various rates. 0-day PHI.

Cabrio EG® at 12-16 oz. per acre. Begin applications before disease development. Do not apply Cabrio® more than once before alternating to a fungicide with a different mode of action. See label to avoid practices that could result in crop injury. See label for tank mix caution. 0-day PHI.

Dithane® and **Penncozeb®** are labeled for use at various rates. 5-day PHI.

RR **Fontelis®** at 12-16 fl. oz. per acre. 1-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Merivon® at 5.5 fl. oz. per acre. Must have supplemental label. 0-day PHI.

Monsoon® at 8 fl. oz. per acre. 7-day PHI.

Pristine® at 12.5-18.5 oz. per acre. 0-day PHI.

RR **Quadris 2.08SC®** at 11.0-15.5 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

Satori® at 11-15.5 fl. oz. per acre. 1-day PHI.

Switch® at 11-14 oz. per acre. 1-day PHI.

Toledo® at 8 fl. oz. per acre. 7-day PHI.

Nematodes

Methyl bromide is the active ingredient for a number of trade names. Generally, it is unavailable. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate® gives adequate control when nematode populations are low to moderate and most of the product is applied under plastic mulch. Apply Vydate® before planting in the spring.

Recommended Products

InLine®. See label for rates.

Telone II® or **Telone C-35®**. See labels for rates. *RUP*.

Vydate L® at 1-2 gals. per acre in 20 gals. of water broadcast. Incorporate 2-4 inches. *RUP*.

Vapam®. See label for rates.

RR This is a reduced-risk pesticide. See page 34 for details.

Phytophthora Crown Rot, Fruit and Foliar Blight

Phytophthora is often associated with heavy rains and fields with poor drainage. Raised beds may help lessen disease severity. The first symptoms are usually observed in low areas. No resistant varieties are available.

Winter/Off-season: Use crop rotations of 4 years or more that do not include solanaceous crops. Avoid fields with a history of a disease.

Planting: Direct-seeded crops may benefit from fungicide-treated seed.

Vine Touch: Apply contact or systemic fungicides when disease threatens and before disease appears. Specialized systemic fungicides are available.

Harvest: Identify fruit problems.

Recommended Products

Apron XL LS® at 6.4 fl. oz. per 100 lbs. seed. *Only for direct-seeded plants.*

Forum 4.18SC® at 6 fl. oz. per acre. 0-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.

RR **Ranman 400SC**® at 2.75 fl. oz. per acre. May be applied in transplant water. 0-day PHI.

RR **Revus 2.09SC**® at 8 fl. oz. per acre. *Suppression only.* 0-day PHI.

Tanos 50WG® at 8-10 oz. per acre. *Suppression only.* 3-day PHI.

Zampro® at 14 fl. oz. per acre. 0-day PHI.

Powdery Mildew

Powdery mildew is primarily a disease of cantaloupe, pumpkin, and squash. This disease does not require leaf wetness for disease initiation or spread.

Some pumpkin varieties have partial resistance to powdery mildew. Fungicide resistance has been detected in the Midwest. Fungicides in Groups 1 and 11 may not be effective. Fungicides that are affected include Cabrio®, Flint®, Quadris®, Satori®, and Topsin®. Alternate fungicides between MOA groups.

Winter/Off-season: Crop rotation and fall tillage are moderately important. Resistant or partially resistant pumpkin cultivars are available.

Vine Touch: Begin systemic fungicide applications at "bush" stage of pumpkin growth. Protect pumpkin vines until approximately 21 days from first harvest.

Recommended Products

Cabrio EG® at 12-16 oz. per acre. 0-day PHI.

RR **Flint**® at 1.5-2.0 oz. per acre. 0-day PHI.

RR **Fontelis**® at 12-16 fl. oz. per acre. 1-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Microthiol 80DF® at 5-10 lbs. per acre. 0-day PHI.

Pristine 39WG® at 12.5-18.5 oz. per acre. 0-day PHI.

Procure 50WS® at 4-8 oz. per acre. 0-day PHI.

RR **Quadris**® at 11-15.4 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

RR **Quintec**® at 4-6 fl. oz. per acre. Supplemental label required. Discontinue use if product causes leaf yellowing. 3-day PHI.

Rally 40W® at 2.5-5.0 oz. per acre. 0-day PHI.

Topsin M 70WP® at 0.25-0.5 lb. per acre. 0-day PHI.

Torino® at 3.4 oz. per acre. 0-day PHI.

Plectosporium Blight

Plectosporium blight primarily affects squash and pumpkin. Although leaves and stems can be affected, only fruit has economically important lesions.

Winter/Off-season: Rotate curcurbit crops 3-4 years and practice fall tillage. Choose fields with well-drained soil.

Vine Touch: Start applying contact/systemic fungicide applications and continue at 7-14 day intervals.

Harvest: Identify fruit problems.

Recommended Products

Cabrio® at 12-16 oz. per acre. 0-days PHI.

RR **Flint**® at 1.5-2.0 oz. per acre. 0-day PHI.

RR **Quadris 2.08SC**® at 11.0-15.4 fl. oz. per acre. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Scab

Scab lesions may be observed on the fruit of most cucurbit crops. Fungicides used for gummy stem blight control may help. Fungicides may be ineffective when temperatures of less than 57°F persist for longer than 9 hours.

Winter/Off-season: Rotate crops 3-4 years and practice fall tillage. Use disease-free seed.

Planting: Fungicides may help to reduce the severity of scab if applied before fruit development.

Harvest: Inspect fruit for symptoms of scab.

Virus Diseases: Cucumber Mosaic (CMV), Papaya Ring Spot (PRSV), Squash Mosaic (SqMV), Watermelon Mosaic (WMV), Zucchini Yellow Mosaic (ZYMV)

Aphids transmit virus diseases, including cucumber mosaic virus, papaya ring spot virus, watermelon mosaic virus, and zucchini yellow mosaic virus. Since these diseases usually appear later in the season, they most often affect pumpkin and squash. All varieties are susceptible to these viruses.

It may help to kill perennial weeds (virus source plants) within 150 feet of planting. Controlling aphids (virus carriers) by insecticides can reduce secondary spread of viruses but does not reduce initial infection and rarely results in any decrease in the incidence of virus symptomatic fruit. Resistant varieties are not yet available. Early planting and development of pumpkins and squash before virus diseases become prevalent may reduce disease severity.

Planting: Earlier planted or earlier maturing pumpkin cultivars will help to avoid severe disease problems.

Vine Touch: Control weeds in and around production area.

Common Cucurbit Viruses and Transmission Sources

Virus	Host Range	Transmission Source
Cucumber Mosaic Virus	wide	aphids[1]
Papaya Ring Spot Virus	Cucurbitaceae	aphids[1]
Squash Mosaic Virus	Cucurbitaceae, Chenopodiaceae	seeds, cucumber beetles
Watermelon Mosaic Virus	Cucurbitaceae, weeds	aphids[1]
Zucchini Yellow Mosaic Virus	Cucurbitaceae	aphids[1]

[1]Aphidborne viruses are non-persistent, thus aphids can begin transmitting the virus after seconds of feeding, and may transmit the virus for only a few hours.

Weed Control for Squash and Pumpkin

For combined weed control options in cucurbits, see page 110.

Insect Control for Squash and Pumpkin

For combined insect control options in cucurbits, see page 114.

RR This is a reduced-risk pesticide. See page 34 for details.

Cucurbit Crops — Cantaloupe, Cucumber, and Watermelon

Melons are warm-season crops that achieve prime quality when grown under warm, sunny conditions. Cool, cloudy weather results in melons with inferior quality. Melons prefer sandy and sandy loam soils. Production on plastic mulch and light soils produces an early crop that commands a premium price.

CANTALOUPE Varieties	Season	Quality	Remarks
Aphrodite	early-mid	excellent	Good shipper, 6-9 lbs.
Athena	early-mid	excellent	Medium net, oval very firm flesh
Crescent Moon	early-mid	good	Heavy net, oval, deep sutures
Eclipse	mid-late	excellent	Heavy net, round, very firm flesh
Odyssey	early-mid	excellent	Round to oval, firm, local market only
Saticoy	late	very good	Good eating quality for direct sales
Starfire (HM 2608)	mid-late	very good	Very large fruit, good netting
Starship	early-mid	very good	Excellent size and net, uniform fruit
Superstar	early	good	Very large fruit, excellent netting
Vienna	early-mid	excellent	Oblong, shallow sutures, holds well
Green-fleshed cantaloupes: Galileo, Levigal, Passport Honeydew melons for trial: Daybreak, Early Dew, Moonshine.			

WATERMELON varieties	Maturity (days)	Ring Color and Pattern	Shape	Approx. wt. (lb.)
Large, Red-Fleshed, Seeded				
Crimson Sweet (open pollinated)	88	green, striped	blocky round	20-30
Denver	85	green, striped	round to oval	20-24
Fiesta	88	dark green, striped	blocky	22-26
Jamboree	88	dark green, broken light green stripes	long blocky	23-27
Olé	85	dark green, striped	oblong/blocky	22-25
Raspa	83	medium green, dark green stripes	blocky	22-24
Regency	82	dark green, striped	blocky oblong	18-22
Royal Majesty	90	green, thin stripes	long oval	30
Royal Sweet	85	light green, striped	blocky oval	20-25
Sangria	85	dark green, striped	long blocky oval	20-26
Stars and Stripes	88	dark green, striped	long, blocky, oval	20-26
Summer Flavor 500	88	medium green, striped	blocky oblong	25-35
Summer Flavor 790	88	dark green, light green stripes	oblong blocky	24-28
Summer Flavor 800	88	dark green, striped	blocky oval	22-26
Top Gun	83	medium green, dark green stripes	globe	21-24
Large, Red-Fleshed, Seedless[1]				
Afternoon Delight	87	mottled stripe	Round	16-20
Crunchy Red	88	medium green stripes, light background	round to oval	15-18
Cooperstown	85	medium green stripes, green background	round to oval	16-22
Fresh Cut	83	dark green, no stripes	round to blocky	18-20
Genesis	85	dark green, striped	round	15-18
Gypsy	85	light green, striped	round to globe	13-17
Imagination	80	Solid dark green	round	12-15
Indiana	76	Jubilee stripe/dark background	round-oval	13-15
Millionaire	90	light green, striped	oblong	13-20
Revolution	84	wide dark stripes on medium background	blocky	18-22
SummerSweet 5244	90	light green, striped	round oval	16-20
SummerSweet 7167	90	light green, striped	oval	15-17
SummerSweet 7197	86	dark green stripes, medium background	oval	16-20
SW 4502	84	allsweet type	oval	16-20
Sweet Delight	88	light green with dark green stripes	oval	17-19
Trillion	95	light green, striped	oval	16-18
Tri-X-313	90	light green, striped	round oval	16-20
Tri-X-Palomar	86	medium green, striped	round	14-17
Troubador	80	dark green stripes, medium green background	blocky	14-17
Wrigley	90	light green with dark green stripes	oval	16-20

[1] Pollenizers must be planted with seedless varieties. Use a long watermelon, such as Royal Jubilee, Royal Sweet, Sangria, or SF 500 as the pollinating variety. Crimson Sweet works well as a pollenizer, but its fruit will be seeded and have a similar appearance to most seedless varieties. Fruitless pollenizer varieties are available. Check with Extension specialists or seed company representatives for more information.

WATERMELON varieties	Maturity (days)	Ring Color and Pattern	Shape	Approx. wt. (lb.)
Small ("Ice-Box" Size), Red-Fleshed, Seeded				
Jade Star	72	dark green	round	10-12
Sweet Beauty	77	dark green, striped	oblong	5-7
Tiger Baby	80	light green, striped	round	7-10
Small ('Personal' Size), Red-Fleshed, Seedless — For Trial				
Bibo	77	medium green, striped	round	5-7
Miniput	80	dark green	round	6-10
Petite Perfection	77	medium green, striped	round	5-7
Yellow-Fleshed Seeded				
AU-Golden Producer	88	light green, striped	blocky round	20-30
Yellow Baby	68	light green, striped	round	9-12
Yellow-Fleshed, Seedless				
Amarillo	80	medium green, striped	round	12-14
Butterball	90	light green, striped	round	15-18
Treasure Chest	80	light green with narrow dark stripes	round	10-15

Watermelon Variety Resistance to Fusarium Wilt[1]

Variety	Company	Type	Resistance[2]
Afternoon Delight	Dwayne Palmer	triploid	+1/2
Crunchy Red	Harris Moran	Triploid	++
Distinction	Syngenta seeds	Triploid	++++
Fascination	Syngenta Seeds	triploid	++++
Fiesta	Syngenta Seeds	diploid	++1/2
Indiana	Seedway	triploid	++
Liberty		triploid	++
Palomar	Syngenta Seeds	triploid	+
Matrix		triploid	+++1/2
Melody		triploid	+++
Regency	Seminis	diploid	++++
Revolution		triploid	+
Royal Sweet	Seminis	diploid	++
Summer Sweet 5244	Abbott & Cobb	triploid	++
Summer Sweet 7167	Abbott & Cobb	triploid	+
SW 4502	Seedway	triploid	+1/2
Trillion	Abbott & Cobb	triploid	+1/2
Triple Threat		triploid	+++
Tri-X-313	Syngenta Seeds	triploid	+1/2
Troubadour	Harris Moran	Triploid	++
Vagabond		triploid	+++1/2

[1] Inclusion of these varieties does not imply endorsement or criticism of any variety or company. Refer to company literature for information on host resistance claims.

[2] The resistance ratings provided here are averages based on several years of greenhouse research. In that research, each watermelon variety was observed after receiving an artificial inoculation with a race 1 strain of the disease. ++++ = good resistance; +++ = moderate resistance; ++ = some resistance; + = little or no resistance.

[3] OP=open pollinated variety included for comparison.

Pollenizer Watermelon Resistance to Fusarium Wilt

Variety	Type	Resistance[1]
Ace	pollenizer	+
Companion	pollenizer	+++1/2
Jenny	pollenizer/edible	++1/2
Mickey Lee	pollenizer/edible	++1/2
Pinnacle	pollenizer	+1/2
Polimax 6017	pollenizer	++
Sidekick	pollenizer	+++1/2
SP-5	pollenizer	++++
Regency	pollenizer/edible	++++

[1] The resistance ratings provided here are averages based on several years of greenhouse and field research. In the greenhouse research, each watermelon variety was observed after receiving an artificial inoculation with a race 1 strain of the disease. ++++ = good resistance; +++ = moderate resistance; ++ = some resistance; + = little or no resistance.

Pollenizer Watermelon Resistance to Anthracnose

Variety	Type	Resistance[1]
Accomplice	pollenizer	++1/2
Ace	pollenizer	+
Mickey Lee	pollenizer/edible	++
Patron	pollenizer	++
Pollen pro	pollenizer	+++
Pollimax 6017	pollenizer	++
Royal Sweet	edible	++
Sweet Harmony	pollenizer	++1/2
SP-4	pollenizer	++++
SP-5	pollenizer	++++
SP-6	pollenizer	++++

[1]The resistance ratings provided here are the averages based on two years of field research. In that research, watermelon varieties were observed after inoculation with race 2 of the disease. ++++ = good resistance; +++ = moderate resistance; ++ = some resistance; + = little or no resistance.

A. CUCUMBER — Slicing Varieties	Season	Disease Resistance[1]
Dasher II	early	1-2-3-4-5-6
General Lee	main	3-4-5-6
Lightning	very early	3-4-6
Speedway	very early	1-2-3-4-5-6
Thunder	very early	3-4-6-7

Beit alpha type (for trial): Socrates
Burpless (for trial): Tasty Green, Burpless 26. Staking recommended. Tasty Green has tolerance to powdery mildew.
[1]Degree of resistance varies according to variety. Disease resistance codes are: 1=angular leaf spot, 2=anthracnose, 3=cucumber mosaic virus, 4=scab, 5=downy mildew, 6=powdery mildew, 7=zucchini yellow mosaic virus.

B. CUCUMBER — Pickling Varieties	Season	Spine Color	Disease Resistance[1]
Calypso	early-mid	white	1-2-3-4-5-6
Carolina	mid	white	1-2-3-4-5-6
Fancipak M	early-mid	white	1-2-3-4-5-6
Green Spear 14	mid	white	1-3-4-5-6
Score[2]	early	white	1-2-3-4-5

[1]Degree of resistance varies according to variety. Disease resistance codes are: 1=angular leaf spot, 2=anthracnose, 3=cucumber mosaic virus, 4=scab, 5=downy mildew, 6=powdery mildew, 7=zucchini yellow mosaic virus.
[2]Machine harvest only.

Female watermelon flowers have an enlarged structure below the petals that will become the fruit if properly pollinated. Male flowers lack this structure.

Spacing

Cantaloupes: Rows 5 to 7 feet apart. Plants 3 to 5 feet apart in row. 1 to 2 plants per hill. Plastic mulch is recommended. Clear mulch is suggested only for earliest plantings in northern areas.

Watermelons: Rows 6 to 12 feet apart. Plants 3 to 6 feet apart in row. One plant per hill. Plastic mulch is recommended for all transplanted watermelons.

Mini- or "personal" watermelons: Rows 6 to 10 feet apart. Plants 1.5 to 2 feet apart in row to allow 12 to 15 square feet per plant.

Cucumbers for fresh market: Rows 4 to 6 feet apart. Plants 15 to 18 inches apart in row.

Pickles (machine harvest): Rows 18 to 20 inches apart. Plants 5 to 7 inches apart in row.

All cucumbers should be planted after the danger of frost is past since they are not frost-tolerant. For proper germination, soil temperature must be above 60°F. Planting too early (when the soil is too cold and wet) will result in poor seedling emergence.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.5. Cantaloupe is particularly sensitive to low soil pH and should be limed to 6.3 to 6.8. If your soil test indicates less than 70 ppm magnesium, use dolomitic limestone, or apply 50 pounds per acre Mg broadcast preplant incorporated.

Preplant: N: 40 to 60 pounds per acre. P_2O_5: 0 to 150 pounds per acre. K_2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For transplants, a starter solution at the rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

Sidedress N: Apply 45 pounds N per acre in a band to either side of the row when plants are rapidly vining. For direct seeded watermelon, the preplant N application can be replaced by an early sidedressing of 40 pounds N per acre when plants show the first set of true leaves followed by the 45 pounds N rate at the rapid vining stage of growth. If heavy rains occur in June, 30 pounds N per acre should be applied through the irrigation system at fruit set (late June to early July).

For cantaloupes and cucumbers grown on plastic mulch, the N rate can be reduced because N losses from leaching are greatly reduced. For this culture system, apply 50 pounds N per acre broadcast preplant over the row just prior to laying the plastic. Sidedress 30 pounds N per acre on either side of the plastic at vining when plant roots have reached the edge of the plastic (mid-June). If you are using trickle irrigation, apply the 50 pounds N per acre preplant and apply 0.5 to 1 pound N per acre daily, or 3 to 6 pounds N weekly through the trickle system until fruit are about 2 inches in diameter.

Irrigation

Cucumbers: Maximum yields and fruit quality will result only if plants receive adequate and timely moisture. Depending on your soil type, obtaining high quality cucumbers requires approximately 1 to 2 inches of water per week. An irregular water supply, particularly during blossoming and fruit development, can affect fruit quality detrimentally and result in increased nubbins or hooked fruit.

Cantaloupes: Cantaloupes are moderately deep rooted and require adequate soil moisture with good drainage. Natural rainfall may not be adequate, so supplemental irrigation may be required, particularly in the early stages of growth. When irrigating, irrigate the soil in the effective root zone to field capacity. A good, steady moisture supply is critical for good melon production. After melons have attained a good size, it is best to reduce irrigation. Reduced irrigation at this time can, in some cases, increase the mature fruit's sugar content. Excessive moisture during fruit ripening can result in poor quality.

Watermelons: Watermelons are deep-rooted plants, so natural rainfall often is adequate, and irrigation may not be cost effective on heavier soils. Adequate soil moisture in the early growth stages will help ensure vigorous growth. Soil moisture also is critical during blossoming and fruit development.

Harvesting

Cucumbers: Unless a once-over mechanical harvester is being used, cucumbers should be harvested at 2 to 4 day intervals to prevent losses from oversized and over mature fruit. Desired harvest sizes range from 5 to 8 inches long and 1.5 to 2 inches in diameter for fresh market. If growing for processors, be sure to understand the specific terms of their contracts at the beginning of the growing season. Prices received are related to the quantity of fruit within specific size ranges as established by either USDA guidelines or by the processor.

Cantaloupes: Harvesting is done manually, and great care must be exercised at picking to harvest only the physiologically mature plants. Fruits must be in the

half or full slip state. Fruit harvested prior to the half slip stage will be too green and will not ripen properly. Shipping under mature fruit has been a problem and should be avoided.

Watermelons: Harvesting watermelons at the correct stage of maturity is critical and difficult. While each cultivar is different, maturity can be determined in several ways, including ground spots changing from white to yellow, browning of tendrils nearest the fruit, ridges appearing on the rind surface, and a hollow or dull sound when "thumped." Melons should be cut from the plant to avoid vine damage and prevent stem-end rot. Leave 1 to 2 inches of stem attached.

Disease Management with the MELCAST System

MELCAST is a disease warning system that can help Indiana farmers schedule their fungicide applications for control of certain diseases of watermelons and cantaloupes. See page 73 for details.

Disease Control for Cantaloupe, Cucumber, and Watermelon

Alternaria Leaf Blight

Alternaria leaf blight (ALB) primarily affects cantaloupe. ALB symptoms may occur on leaves from May through harvest.

Winter/Off-season: Rotate crops at least 2 years and practice fall tillage.

Vine Touch: Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, www.the-education-store.com.

Harvest: Fungicide applications are unnecessary within 2-3 weeks of final harvest.

Recommended Products

Bravo®, Echo®, Equus®, and **Initiate®** are labeled for use at various rates. 0-day PHI.

Cabrio EG® at 12-16 oz. per acre. See label to avoid practices that could result in crop injury. See label for tank mix caution. 0-day PHI.

Dithane®, Manzate®, and **Penncozeb®** are available for use at various rates. 5-day PHI.

RR **Fontelis®** at 12-16 fl. oz. per acre. See label for greenhouse uses. 1-day PHI.

RR **Gavel 75DF®** at 1.5-2 lbs. per acre. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Luna Experience® at 8-17 fl. oz. per acre. *Watermelon only.* 7-day PHI.

Luna Privilege® at 6.84 fl. oz. per acre. *Watermelon only.* 0-day PHI.

Luna Sensation® at 7.6 fl. oz. per acre. *Watermelon only.* 0-day PHI.

Merivon® at 4-5.5 fl. oz. per acre. Must have supplemental label. 0-day PHI.

Pristine 38WG® at 12.5-18.5 oz. per acre. 0-day PHI.

RR **Quadris 2.08SC®** at 11.0-15.5 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

Satori® at 11-15.5 fl. oz. per acre.

Switch® at 11-14 oz. per acre. 1-day PHI.

Tanos 50WG® at 8 oz. per acre. 3-day PHI.

Angular Leaf Spot

Angular leaf spot is a cool weather disease, normally restricted to the spring or early summer. Angular leaf spot may be transmitted via seed.

Dithane® and Manzate® may help manage angular leaf spot when used with fixed copper products.

Anthracnose

Race 1 of the fungal pathogen that causes anthracnose affects mainly cucumber —some watermelon varieties are resistant to Race 1. Race 2 affects mainly watermelon. Lesions of this disease may be observed from transplant stage through harvest on leaves, stems, and fruit.

Winter/Off-season: Rotate crops at least 3 years and practice fall tillage. Rotation with non-cucurbit crops will decrease the threat of anthracnose in future years. May be seedborne.

Greenhouse: Scout for disease. Apply fungicide labeled for greenhouse if disease threatens.

Planting: Inspect seedlings. Avoid planting diseased seedlings.

Vine Touch: Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, www.the-education-store.com.

Harvest: Inspect fruit. Avoid saving seed.

RR This is a reduced-risk pesticide. See page 34 for details.

Recommended Products

Bravo®, Echo®, Equus®, and **Initiate®** are labeled for use at various rates. 0-day PHI.

Cabrio EG® at 12-16 oz. per acre. See warnings under Alternaria leaf blight. 0-Day PHI.

Dithane®, Manzate®, and **Penncozeb®** are available for use at various rates. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Luna Experience® at 17 fl. oz. per acre. *Watermelon only*. 7-day PHI.

Luna Sensation® at 7.6 fl. oz. per acre. *Watermelon only.* 0-day PHI.

Merivon® at 5.5 fl. oz. per acre. Must have supplemental label. 0-day PHI.

Pristine 38WG® at 18.5 oz. per acre. 0-day PHI.

RR **Quadris 2.08SC®** at 11-15.4 fl. oz. per acre. 1-day PHI.

Quadris Opti® 3.2 pts. per acre 7 day PHI.

Tanos 50WG® at 8 oz. per acre. 3-day PHI.

Bacterial Fruit Blotch

The occurrence of bacterial fruit blotch (BFB) is highly correlated with seed contaminated with the causal bacterium. BFB symptoms may occur on leaves in the transplant greenhouse or in the field where they may be easily overlooked. However, only lesions on mature fruit are of economic importance. The pathogen is primarily seedborne (introduced with contaminated seed), but may overwinter on crop debris in greenhouses and in the field.

Many cucurbit crops may be affected, but bacterial fruit blotch is most often observed on watermelon and cantaloupe.

Winter/Off-season: Fall-plow contaminated fields and plant to crops other than cucurbits for at least 2 years. Subsequent grain crops are suggested for the rotation so that broadleaf herbicides will kill volunteer seedlings in the spring. Purchase seed tested for BFB.

Greenhouse: Scout and apply fixed copper if disease threatens. Sanitize greenhouse thoroughly after each generation of transplants.

Planting: Avoid planting diseased seedlings.

Vine Touch: Fixed copper compounds may lessen the impact of the disease.

Harvest: Inspect fruit. Avoid saving seed.

Recommended Products

Actigard® at 0.5-1 oz. per acre. Must apply with two of the fixed copper product applications described below. 0-day PHI.

In situations where fruit blotch threatens, apply copper products as outlined below to help reduce the rate of disease spread.

Several **fixed copper** products are labeled at various rates. Apply fixed copper 2 weeks prior to the opening of the first female bloom, at first bloom, and 2 weeks after the first female bloom. No more than 6 applications per season.

Bacterial Wilt

Bacterial wilt primarily affects cantaloupe and cucumber. Striped or spotted cucumber beetle feeding from the seedling stage until shortly after vine touch spreads the causal bacterium from plant to plant. Symptom expression may not occur until cantaloupe fruit near maturity, at which point it is too late to stop the spread of the disease.

Winter/Off-season: The disease is unaffected by crop rotation.

Planting: Apply systemic insecticides such as Admire® or Platinum® (see insect section). Apply contact insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply insecticides only when beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

Damping-off

Practice good greenhouse sanitation. The best way to prevent damping off of seedlings in the greenhouse is to keep the greenhouse area clean. See Transplant Production, page 20.

Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Recommended Products

Previcur Flex®. See label for details about for managing damping-off caused by Pythium species.

Ridomil Gold SL® at 1-2 pts. per acre. For damping-off caused by Pythium.

Scab

Scab lesions may be observed on the fruit of most cucurbit crops. Fungicides used for Gummy stem blight control may help. Fungicides may be ineffective when temperatures of less than 57°F persist for longer than 9 hours.

Winter/Off-season: Rotate crops 3-4 years and practice fall tillage. Many cucumber varieties have resistance. Use disease-free seed.

Planting: Fungicides may help to reduce the severity of scab if applied before fruit development.

Harvest: Inspect fruit for symptoms of scab.

Downy Mildew

This fungal disease does not survive in the Midwest and therefore is spread by wind. Downy mildew may not occur in the Midwest until August or September and in some years, does not occur in the Midwest at all.

Strains of the downy mildew fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin (group 11) fungicides (such as Cabrio®, Flint®, Pristine®, Quadris®, Reason®, Satori®) and fungicides with the active ingredient mefenoxam (such as Ridomil®) are particularly susceptible to resistance. See Fungicide Resistance Management (page 72) for more information.

Winter/Off-season: The disease is unaffected by crop rotation. Several cucumber varieties have genetic resistance to downy mildew. Host resistance may vary depending on the strain of the downy mildew fungus present.

Planting: Begin scouting in July. Follow disease progress in the Purdue Extension *Vegetable Crops Hotline* bulletin or at cdm.ipmpipe.org. Apply specialized systemic downy mildew fungicides only if disease is observed in the area.

Recommended Products

Bravo®, Echo®, Equus®, and **Initiate®** are labeled for use at various rates. 0-day PHI.

Cabrio EG® at 8-12 oz. per acre. See warnings under Alternaria leaf blight. 0-day PHI.

Curzate 60DF® at 3.2-5.0 oz. per acre. 3-day PHI.

RR **Flint®** at 4 oz. per acre. 16 oz. per acre per season. 0-day PHI.

Forum 4.18SC® at 6 fl. oz. per acre. 0-day PHI.

RR **Gavel 75DF®** 1.5-2.0 lbs. per acre. 5-day PHI.

Mancozeb products (including Dithane®, Manzate® or Penncozeb®) are labeled at various rates. 5-day PHI.

Several **phosphite** or **phosphorous acid** products are labeled at various rates (including Phostrol®, Prophyt®) Label includes several different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank mixing. 0-day PHI.

Presidio® at 3-4 fl. oz. per acre. 2-day PHI.

Previcur Flex® at 1.2 pts. per acre. 2-day PHI.

Pristine 38WG® at 12.5-18.5 oz. per acre. 0-day PHI.

RR **Quadris 2.08®** at 11-15.5 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

Reason 500 SC® at 5.5 fl. oz. per acre. 14-day PHI.

RR **Ranman®** at 2.1-2.75 lbs. per acre. 0-day PHI.

RR **Revus 2.09SC®** at 8 fl. oz. per acre. *Suppression only*. 0-day PHI.

Ridomil Gold Bravo® at 2 lbs. per acre, or **Ridomil Gold MZ®** at 2 lbs. per acre (dry), or at 2.5 pts. per acre (flowable). 0-day PHI for Ridomil Gold Bravo®. 5-day PHI for Ridomil Gold MZ®.

Tanos 50DF® at 8 oz. per acre. 3-day PHI.

Zampro® at 14 fl. oz. per acre. 0-day PHI.

Fusarium Fruit Rot

No resistant varieties are available. Fruit with Fusarium fruit rot are often observed from fields where other disease or cultural problems are present.

Winter/Off-season: Rotate with noncucurbit crops at least 4 years. Avoid fields with a history of disease. May be seedborne.

Planting: Manage foliar diseases for better fruit health. Avoid other fruit diseases, such as bacterial fruit spot or Phytophthora blight.

Harvest: Identify fruit problems.

Fusarium Wilt in Cantaloupe

Plant resistant cantaloupe cultivars. Several cultivars have good resistance to strains of Fusarium found in Indiana and Illinois.

Fusarium Wilt in Watermelon

Plant watermelon cultivars with partial resistance. See table on page 101. Rotate with noncucurbit crops to decrease incidence of wilt.

Recommended Products

Proline® at 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting.

Gummy Stem Blight/Black Rot

Gummy stem blight may occur on transplants in the greenhouse through harvest. The leaves and stems of cantaloupe and watermelon may be affected. Occasionally, fruit are affected, which is known as black rot.

Strains of the gummy stem blight fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin fungicides in Group 11 (such as Cabrio®, Flint®, Merivon®, Pristine®, Quadris®) and fungicides with the active ingredient boscalid Group 7 (such as Fontelis®, Merivon®, Pristine®) are particularly susceptible to resistance. See Fungicide Resistance Management (page 72) for more information. Tank mix these products with products that have a different mode of action in situations where resistance may be a factor.

Winter/Off-season: Rotate crops at least 3 years and practice fall tillage. May be seedborne.

Greenhouse: Scout for disease. Apply fungicide labeled for greenhouse if necessary.

Planting: Avoid planting diseased seedlings in the field.

Vine Touch: Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, www.the-education-store.com.

*Harvest***:** Identify fruit problems.

Recommended Products

Bravo®, Echo®, Equus®, and **Initiate®** are labeled for use at various rates. 0-day PHI.

Cabrio EG® at 12-16 oz. per acre. 0-day PHI.

Dithane® and **Penncozeb®** are labeled for use at various rates. 5-day PHI.

Fontelis 1.67SC® at 12-16 fl. oz. per acre. See label for greenhouse uses. 1-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Luna Experience® at 17 fl. oz. per acre. *Watermelon only.* 7-day PHI.

Luna Privilege® at 6.84 fl. oz. per acre. *Watermelon only.* 0-day PHI.

Merivon® at 5.5 fl. oz. per acre. Must have supplemental label. 0-day PHI.

Monsoon® at 8 fl. oz. per acre. 7-day PHI.

Pristine® at 12.5-18.5 oz. per acre.

RR **Quadris 2.08SC®** at 11.0-15.5 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

Satori® at 11-15.5 fl. oz. per acre. 1-day PHI.

Switch® at 11-14 oz. per acre. 1-day PHI.

Toledo® at 8 fl. oz. per acre. 7-day PHI.

Nematodes

Methyl bromide is the active ingredient for a number of trade names. Generally, it is unavailable. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate® gives adequate control when nematode populations are low to moderate and most of the product is applied under plastic mulch. Apply Vydate® before planting in the spring.

Recommended Products

Telone II® or **Telone C-35®**. See labels for rates. *RUP*.

Vydate L® at 1-2 gals. per acre in 20 gals. of water broadcast. Incorporate 2-4 inches. *RUP*.

Vapam®. See label for rates.

Phytophthora Root Rot and Foliar Blight

Phytophthora is often associated with heavy rains and fields with poor drainage. Raised beds may help lessen disease severity. The first symptoms are usually observed mid- to late season. No resistant varieties are available.

Winter/Off-season: Use crop rotations of 4 years or more that do not include solanaceous crops. Avoid fields with a history of a disease.

Planting: Direct-seeded crops may benefit from fungicide-treated seed.

Vine Touch: Apply contact or systemic fungicides when disease threatens and before disease appears. Specialized systemic fungicides are available.

Harvest: Identify fruit problems.

Recommended Products

Apron XL LS® at 6.4 fl. oz. per 100 lbs. seed. *Direct-seeded plants only.*

Forum 4.18SC® at 6 fl. oz. per acre. 0-day PHI.

RR **Gavel 75DF**® at 1.5-2 lbs. per acre. 5-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.

RR **Ranman 400SC**® at 2.75 fl. oz. per acre. May be applied in transplant water. 0-day PHI.

RR **Revus 2.09SC**® at 8 fl. oz. per acre. *Suppression only.* 0-day PHI.

Tanos 50WG® at 8-10 oz. per acre. *Suppression only.* 3-day PHI.

Zampro® at 14 fl. oz. per acre. 0-day PHI.

Powdery Mildew

Many cucumber and cantaloupe varieties have good resistance to powdery mildew. Watermelon usually are not affected by powdery mildew in the Midwest. This disease does not require leaf wetness for disease initiation or spread.

Fungicide resistance has been detected in the Midwest. Fungicides in Groups 1 and 11 may not be effective. Fungicides that are affected include Cabrio®, Flint®, Merivon®, Quadris®, Satori®, and Topsin®. Alternate fungicides between MOA groups.

Winter/Off-season: Crop rotation and fall tillage are moderately important. Resistant or partially resistant cantaloupe cultivars are available.

Vine Touch: Begin systemic fungicide applications 7-14 days before harvest (cantaloupe).

Recommended Products

RR **Flint**® at 1.5-2.0 oz. per acre. 0-day PHI.

RR **Fontelis 1.67SC**® at 12-16 fl. oz. See label for greenhouse uses. 1-day PHI.

Luna Experience® at 6-17 fl. oz. per acre. *Watermelon only.* 7-day PHI.

Luna Sensation® at 4-7.6 fl. oz. per acre. *Watermelon only.* 0-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.

Merivon® at 4-5.5 fl. oz. per acre. Must have supplemental label. 0-day PHI.

Microthiol 80DF® at 5-10 lbs. per acre, or other **sulfur** formulations. 0-day-PHI.

Pristine® at 12.5-18.5 oz. per acre. 0-day PHI.

Procure 50WS® at 4-8 oz. per acre. 0-day PHI.

RR **Quadris**® at 11-15.4 fl. oz. per acre. 1-day PHI.

Quadris Opti® at 3.2 pts. per acre. 1-day PHI.

RR **Quintec**® at 4-6 fl. oz. per acre. *Not for cucumber.* Must have supplemental label. 3-day PHI.

Rally 40W® at 2.5-5.0 oz. per acre. 1-day PHI.

Satori® at 11-15 fl. oz. per acre.

Topsin M 70WP® at 0.25-0.5 lb. per acre. 0-day PHI.

Torino® at 3.4 oz. per acre. 0-day PHI.

Virus Diseases: Cucumber Mosaic Virus (CMV), Zucchini Yellow Mosaic Virus (ZYMV), Watermelon Mosaic Virus (WMV)

Aphids transmit virus diseases, including cucumber mosaic virus, papaya ring spot virus, watermelon mosaic virus, and zucchini yellow mosaic virus. All varieties are susceptible to these viruses.

It may help to (1) kill perennial weeds (virus source plants) within 150 feet of planting and (2) control aphids (virus carriers). Resistant varieties are not yet available. Early planting and development of pumpkins and squash before virus diseases become prevalent may reduce disease severity.

Planting: Earlier planted or earlier maturing pumpkin cultivars will help to avoid severe disease problems.

Vine Touch: Control weeds in and around production area.

Common Cucurbit Viruses and Transmission Sources

Virus	Host Range	Transmission Source
Cucumber Mosaic Virus	wide	aphids[1]
Papaya Ring Spot Virus	Cucurbitaceae	aphids[1]
Squash Mosaic Virus	Cucurbitaceae, Chenopodiaceae	seeds, cucumber beetles
Watermelon Mosaic Virus	Cucurbitaceae,weeds	aphids[1]
Zucchini Yellow Mosaic Virus	Cucurbitaceae	aphids[1]

[1]Aphidborne viruses are non-persistent, thus aphids can begin transmitting the virus after seconds of feeding, and may transmit the virus for only a few hours.

Product/Disease Ratings for All Cucurbits

Product (REI/PHI)[1]	**Common name** MOA or FRAC code: fungicides with a number as the MOA code should be tank mixed or alternated with a different MOA code according to the label.	Alternaria leaf blight	Anthracnose	Bacterial fruit blotch	Bacterial fruit spot	Downy mildew	Gummy stem blight/black rot	Plectosporium blight	Phytophthora blight	Powdery mildew	Scab	Comments
Agri-Fos®, Phostrol®, Prophyt® (4/0)	phosphorus acid/phosphite (33)					G[2]	F		F			
Aliette® 12/1/2)	fosetyl-Al (33)					F			P			
Bravo®, Echo®, Equus®, Initiate® (12/0)	chlorothalonil (M)	G	G			F	G	G	P	F	G	
Cabrio® (12/0)	pyraclostrobin (11)	G	G			F	F	G		F		There may be resistance issues with downy mildew and gummy stem blight.
copper (active ingredient) (24/0)	copper (M)	P	P	G	F	P	P					
Curzate® (12/3)	cymoxanil (27)					G						
Dithane®, Manzate®, Penncozeb® (24/5)	mancozeb (M)	G	G			F	G	G			G	
Flint® (12/0)	trifloxystrobin (11)					F		F		F		
Fontelis® (12/1)	penthiopyrad (7)	G					G			G		There may be resistance issues with downy mildew and gummy stem blight.
Gavel® (48/5)	mancozeb (M), zoxamide (22)	G				G			G			
Inspire Super® (12/7)	difenoconazole (3), cyprodinil (9)	G	G				G	G		G		
Luna Privilege® (12/3)	fluopyram (7)	G					G			G		Watermelon only.
Luna Sensation® (12/0)	trifloxystrobin (11), fluopyram (7)	G	G							G		Watermelon only.
Merivon® (12/0)	fluxapyroxad (7), pyraclostrobin (11)	F	F				F			G		
Monsoon®, Onset®, Toledo® (12/7)	tebuconazole (3)						G			G		
Presidio 4SC® (12/2)	fluopicolide (43)					G			G			
Previcur Flex® (12/2)	propamocarb (28)					G						Has greenhouse label for damping-off
Pristine® (12/0)	boscalid (7), pyraclostrobin (11)	G	G			F	F			G		There may be resistance issues with downy mildew and gummy stem blight.
Procure® (12/0)	triflumizole (3)									G		
Quadris®, Satori® (4/1)	azoxystrobin (11)	G	G			F	F	G		F		There may be resistance issues with downy mildew and gummy stem blight.
Quadris Opti® (12/1)	azoxystrobin (11), chlorothalonil (M)	G	G			F	F			F		
Quintec® (12/3)	quinoxyfen (13)									G		Contact fungicide with single mode of action
Rally® (24/0)	mycolobutanil (3)									G		
Ranman® (12/0)	cyazofamid (21)					G			G			
Revus® (4/0)	mandipropamid (40)					F			G			
Ridomil Gold Bravo® (48/0)	mefenoxam (4), chlorothalonil (M)		G			F	G					
Switch 62.5WB® (12/1)	cyprodinil (9), fludioxanil (12)	G					G			F		
Tanos® (12/3)	cymoxanil (27), famoxadone (11)	G	G	S		P			S			
Topsin M® (12/0)	thiophanate-methyl (1)		G				F			P		
Torino® (4/0)	cyflufenamid (U6)									G		
Zampro (12/0)	ametoctradin (45), dimethomorph (40)					G			G			See label for directions for at planting drench.

[1]REI (re-entry interval) in hours: do not enter or allow workers to enter areas treated during the REI period. PHI (pre-harvest interval) in days: the minimum time that must pass between the last pesticide application and crop harvest.

[2]Fungicide rating code: G=good. F=fair. P=poor. S=suppression only. Based on research and experience of the authors.

Weed Control for All Cucurbits

Weed control methods in cucurbits vary by production system. The challenges for those who rely on herbicides include the chance of injuring crops under adverse weather, the relatively short residual of preemergence herbicides, and the lack of a broad-spectrum postemergence broadleaf herbicide that can be applied over the top of the crop.

For cucurbits that are no-till direct-seeded into a killed crop (such as pumpkins after soybeans, rye cover crop, or wheat) growers often use a burndown herbicide with a preemergence herbicide. If residue and cucurbit vines are not sufficient to suppress later-emerging weeds, growers may use postemergence herbicides, or shielded applications of nonselective herbicides.

For cucurbits direct-seeded into tilled soil, growers often combine one or more preemergence herbicides at planting with one or more cultivations. Sometimes, growers also apply a preemergence herbicide at the last cultivation to improve control of late-emerging weeds. If needed, growers may use postemergence herbicides or shielded applications of nonselective herbicides.

When cucurbits are transplanted into plastic mulch, some growers apply a premergence herbicide under the mulch as well as between the rows. Other growers only apply between the rows. Growers may also use one or more cultivations, and if needed, postemergence herbicides or a shielded application of a nonselective herbicide.

In organic production, organic mulches, plastic mulch, cultivation, and hand-weeding are common. Planting on the square will allow cultivation in two directions.

Weed pressure may be substantially reduced when growers prepare seedbeds several weeks in advance of planting and kill the first one or two flushes of weeds before planting without stirring up new weed seeds. Cucurbits lend themselves to this stale seedbed practice because they are often planted after common weeds have emerged in tilled soil.

The more quickly cucurbit vines cover the soil surface, the better they will suppress late-emerging weeds. Closer row spacing promotes rapid vine cover, and growers can increase in-row spacing to maintain a constant plant population. Uniform plant spacing in the row will also promote uniform vine cover. Seeding equipment that allows large gaps in direct-seeded crops usually leads to weed patches where the crop population is lower.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Application Broadleaves and Grasses

Recommended Products

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae/gal. (4 lbs. isopropylamine salt/gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae/gal. (5 lbs. potassium salt/gal.) at 0.66-3.3 qts. per acre. Broadcast at least 3 days before seeding or transplanting, or apply between crop rows with hooded or shielded sprayer. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. 14-day PHI.

Gramoxone Inteon 2L® at 2-4 pts. per acre. Include 1 qt. of COC or 4-8 fl. oz. of NISper 25 gals. of spray solution. Apply before seeding or transplanting, or after seeding but before crop emergence. *RUP*.

Burndown or Directed/Shielded Application Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. *Controls broadleaves only*. Do not apply before direct seeding. Apply prior to transplanting or apply between crop rows with hooded sprayer. Do not apply before direct seeding. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

Sandea® at 0.5-1.0 oz. per acre. Apply between rows. Avoid contact with crop. 30-day PHI for cucumber, squash and pumpkin. 57-day PHI for cantaloupe and watermelon.

Preemergence Broadleaves and Grassses

Recommended Products

Command 3ME® at the following rates:

Cantaloupe and watermelon: 0.4-0.67 pt. per acre.

Cucumber: 0.4-1.0 pt. per acre. 45-day PHI.

Summer squash: 0.67-1.33 pts. per acre. 45-day PHI.

Winter squash and processing pumpkin: 0.67-2 pts. per acre. 45-day PHI.

Not for jack-o-lantern pumpkins. See label for sensitive varieties. Apply prior to seeding or transplanting, or after seeding before crop emergence. Does not control pigweed and related species. Rates below 1 pt. will only suppress weeds. May cause temporary bleaching of crop leaves.

Curbit 3EC® at 3-4 pts. per acre. Use lower rates on coarse soils. *Direct-seeded crops*: apply to soil surface within 2 days after seeding. Do not incorporate. *Transplants*: apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top of plants. Under cool temperatures may cause crop injury or failure.

Dual Magnum® at the following rates:

Cantaloupe and watermelon in Indiana and Ohio only: 0.67-1.27 pts. per acre. For crops on plastic mulch, apply between rows after laying mulch, but before crop emergence or transplanting. For crops on bare ground, apply before transplanting, or after seeding before crop emergence. On bare ground, the herbicide may be broadcast or applied just between between rows. There is less risk of crop injury if applied between rows, and if melons are transplanted rather than seeded. Do not exceed 1.27 pts. per acre or 1 application per crop per season. 60-day PHI.

Cucumber in Indiana and Ohio only: 0.67-1 pt. per acre. Apply after seeding before weeds or crop emerge, or apply broadcast after cucumbers have 1-2 true leaves. Do not exceed 1 pt. per acre or 1 application per crop per season. 30-day PHI.

Pumpkin: 1-1.33 pts. per acre to row-middles only: Apply between rows or hills. Leave an untreated area at least 1 foot wide over the planted row, or at least 6 inches from planted seed or pumpkin leaves. 30-day PHI.

Winter squash in Indiana and Ohio only: 1-1.3 pts. per acre. Apply after seeding before weeds or crop emerge. Injury to winter squash may occur if applied directly over the planted row or hill. Consider leaving an untreated strip directly over seed. Do not exceed 1.3 pt. per acre per crop. 30-day PHI.

Prowl H2O® at 2.1 pts. per acre. *Cantaloupe and watermelon only. Apply to row middles only.* Use a shielded sprayer. Apply before transplanting or before emergence of direct-seeded crop. A second application may be made before vines run. Wait at least 21 days between applications. Do not exceed 2.1 pts. per acre per application or 4.2 pts. per acre per season. 35-day PHI.

Sinbar® at 2-4 oz. per acre. *Watermelons only*. Do not use on sand or gravel soils. Not recommended on soils with less than 1% organic matter due to crop injury potential. Apply pre-transplant to bare ground, or pre-transplant under plastic mulch, or to row middles. For direct-seeded crops on bare ground, apply after planting before crop emerges. Do not allow spray to contact crop. 70-day PHI. Do not plant other crops within 2 years of application.

Strategy® at 2-6 pts. per acre. Strategy® is a premix containing the active ingredients of Command® and Curbit®. *Direct-seeded crops*: apply to soil surface within 2 days after seeding. Do not incorporate. *Transplants*: apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top of plants. Under cool temperatures may cause crop injury or failure. 45-day PHI for cucumbers and squash.

Trifluralin products at 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre. Use lowest rate on coarse soils. Apply as a directed spray between rows after plants have 3-4 leaves and incorporate. 60-day PHI for watermelon. 30-day PHI for all others.

Preemergence Broadleaves

Recommended Products

League® at 4-6.4 oz. per acre. *Cantaloupe and watermelon only*; *not for cucumber, squash, or pumpkin*. Use the higher rate in fields with a known history of nutsedge. Apply between rows after plants are well-established and at least 5 inches wide. Avoid contact with crop and plastic mulch (if present). If emerged weeds are present include a Valent-recommended surfactant to control yellow nutsedge and labeled broadleaf weeds that are 1-3 inches tall. Do not exceed 1 application and 6.4 oz. per acre per year. 48-day PHI.

Sandea® at the following rates:

Direct-seeded pumpkins and winter squash on bare ground: 0.5-0.75 oz. per acre.

Direct-seeded cucumber, cantaloupe, and processing pumpkin on bare ground: 0.5-1 oz. per acre. Apply after seeding but prior to cracking.

Pretransplant cucumber, cantaloupe, pumpkin, and winter squash: 0.5-0.75 oz. per acre.

Pretransplant cucumber and cantaloupe: up to 1 oz. per acre. Apply to soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait 7 days after application and mulch laying before transplanting.

Preemergence and pretransplant applications are allowed on watermelon in Indiana, Illinois, Kansas, and Missouri.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. *Cantaloupe and watermelon only*. Apply when plants have 4-5 true leaves and growing conditions favor good plant growth. Crop injury may occur if applied under unfavorable growing conditions or earlier than recommended.

Prefar 4E® at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 in. or apply after seeding before crop emerges and irrigate within 24 hours.

Postemergence Broadleaves

Recommended Products

Aim EC®. See details for Burndown or Directed/Shielded Application Broadleaves.

League®**.** See details above for Preemergence. Also controls nutsedge.

Sandea® at the following rates:

Pumpkin and winter squash on bare ground: 0.5-0.67 oz. per acre.

Cucumber, cantaloupe, and processing pumpkin on bare ground: 0.5-1 oz. per acre.

Not for for summer squash or watermelon on bare ground. For crops on plastic mulch, see details under Burndown or Directed/Shielded Application Broadleaves. Apply after the crop has 3-5 true leaves and is actively growing but before female flowers open. Use lower rates on coarse soils with low organic matter. Add 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications per crop cycle. 30-day PHI for cucumber, squash, and pumpkin. 57-day PHI for cantaloupe.

Postemergence Grasses

Recommended Products

Poast 1.5E® at 1-1.5 pts. per acre. Use with 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 3 pts. per acre per season. 14-day PHI.

Select Max® at 9-16 fl. oz. per acre, or **2EC formulations of clethodim products** at 6-8 fl. oz. per acre. Use low rates for annual grasses. Use high rates for perennial grasses. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 64 fl. oz. of Select Max® per acre per season. Do not exceed 32 fl. oz. of 2EC formulations per acre per season. 14-day PHI.

Herbicides for All Cucurbits[1]

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop[2]					Incorporated	Timing Relative to Weeds		Weed Groups Controlled			Crops[3]					
		Before seeding	After seeding before emergence	Before transplanting	Post emergence - between rows only	Postemergence		Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Cucumber	Cantaloupe	Watermelon	Squash, summer	Suqash, winter	Pumpkin
Aim EC® (12h/-)	carfentrazone			X	X				X		X	X	X	X	X	X	X	X
Command 3ME® (12h/45d)	clomazone	X	X	X				X		X	X	X	X	X	X	X	X	*
Curbit 3EC® (24h/-)	ethalfluralin		X		X		no	X		X	X		X	X	X	X	X	X
Dacthal W-75®, Dacthal Flowable® (12h/-)	DCPA					X		X		X				X	X			
Dual Magnum® (24h/30d)	s-metolachlor	X between rows	X between rows	X between rows	X			X		X	X							X
Gramoxone Inteon 2L® (12h to 24h/-)	paraquat	X	X	X	X				X	X	X	X	X	X	X	X	X	X
League® (12h/48d)	imazosulfuron				X			X	X		X	X		X	X			
Poast® (12h/14d)	sethoxydim					X			X	X			X	X	X	X	X	X
Prefar 4E® (12h/-)	bensulide	X	X	X			yes	X		X			X	X	X	X	X	X
Prowl H2O (24h/35d)	pendimethalin		X between rows	X between rows	X			X		X	X			X	X			
Roundup®, others (12h/14d)	glyphosate	X	X	X	X				X	X	X	X	X	X	X	X	X	X
Sandea® (12h/30d to 57d)	halosulfuron		X	X	X	X		X	X		X	X	X	X	X	X	X	X
Select Max®, others (12h/14d)	clethodim					X			X	X			X	X	X	X	X	X
Sinbar® (12h/70d)	terbacil		X	X	X			X			X				X			
Strategy® (24h/ 45d)	clomazone and ethalfluralin		X		X		no	X		X	X	X	X	X	X	X	X	X
Treflan®, others (12h/30d to 60d)	trifluralin				X		yes	X		X	X		X	X	X	X	X	X

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted for at least one crop.
[3]X=may be used for that crop. *=Processing crops only.

Insect Control for All Cucurbits

Seedcorn Maggots and Cucumber Beetles (in seed beds)

Treat seeds with a combination fungicide/insecticide, such as FarMore FI400®. Early clean plowing of cover crops will generally result in less damage to seedling plants in the field.

Seedcorn Maggot and Wireworm

Recommended Products

Capture LFR® at 0.39-0.49 fl. oz. per 1,000 linear ft. of row ft. See label. *RUP*.

Aphids and Leafhoppers

Conserve natural enemies: limiting insecticide use will conserve predators and parasites that help control aphid populations. Monitor: look for the presence of predators or parasitized aphids. Several predators per aphid colony will probably bring the aphid population under control without insecticide. Killing aphids with insecticides cannot prevent the virus diseases they carry.

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. Aphids only. Do not exceed 11 oz. per acre per season. 0-day PHI.

Admire PRO® at 7.0-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. 21-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. *Leafhoppers only*. Do not exceed 48 fl. oz. per acre per season. 3-day PHI. *RUP*.

RR **Assail 30SG**® at 2.5-5.3 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. *Potato leafhoppers only*. Do not exceed 11.2 fl. oz. or 4 applications per acre per season. Allow 7 days between applications. 0-day PHI. *RUP*.

Belay 2.13SC® at 3-4 fl. oz. per acre. Do not apply during bloom. 7-day PHI.

Beleaf 50SG® at 2-2.8 oz. per acre. *Aphids only.* 0-day PHI.

Brigade 2EC® at 2.6-6.4 fl. oz. per acre, or **Brigade WSB**® at 8-16 oz. per acre. *Leafhoppers only*. Do not exceed 19.2 fl. oz. per acre per season. 3-day PHI. *RUP*.

Closer 2SC® at 1.5-2 fl. oz. per acre. *Aphids only.* 1-day PHI.

Dimethoate 400® or **Dimethoate 4E**® at 0.5-1 pt. per acre, or **Dimethoate 2.67EC**® at 0.75-1.5 pts. per acre. *Cantaloupe and watermelon only*. 3-day PHI.

Endosulfan 3EC® at 0.67-1.33 qts. per acre. Do not exceed 4 applications per acre per season. *Pumpkin and winter squash only*. Do not use after July 31, 2015. 11-day PHI.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. *Aphids only*. Do not exceed 5.5 oz. per acre per season. 7-day PHI.

Lannate SP® at 0.5-1 lb. per acre. *Aphids only*. *Not for pumpkin or winter squash.* 1-day PHI for applications of 0.5 lb. 3-day PHI for applications of more than 0.5 lb. *RUP*.

Malathion 5EC® at 1.5-2.8 pts. per acre, or **Malathion 57EC**® at 1.5 pts. per acre. *Aphids only.* 1-day PHI.

M-Pede® at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. *Aphids only*. 30-day PHI.

Pounce 25WP® or **Ambush 25W**® at 12.8 oz. per acre. *Leafhoppers only*. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 6.4 lbs. per acre. 0-day PHI. *RUP*.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. 1-day PHI. *RUP*.

Cucumber Beetles only (preplant)

Recommended Products

Admire PRO® at 7.0-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or smaller, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 24 fl. oz. per acre per season. 21-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. 30-day PHI.

Cucumber Beetles, Squash Bugs, and Squash Vine Borers

Cantaloupe growers may consider using unbaited AM Yellow Sticky Traps for sampling cucumber beetles. Monitor fields frequently (2-3 times per week) to detect mass emergence of beetles in the spring. Focus insecticide applications on periods of heavy beetle activity. Evening sprays will reduce bee kill.

Recommended Products

Apply throughout the season when beetles exceed threshold.

Admire PRO® at 7-10.5 fl. oz. per acre. Apply preplant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. 21-day PHI.

Ambush 25W® at 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air or 20 gallons finished spray per acre with ground equipment. Do not exceed 6.4 lbs. per acre. 0-day PHI. *RUP*.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 3-day PHI. *RUP*.

RR **Assail 30SG**® at 2.5-5.3 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.

Azera® at the following rates:

Squash bug nymphs: 32 fl. oz. per acre.

Adult squash bugs and cucumber beetles: 48 fl. oz. per acre.

Use higher rates (48 fl. oz. per acre) when pest pressure is extreme or plant canopy is dense. Do not exceed 10 applications per season. Do not reapply within 3 days except under extreme pest pressure. 0-day PHI.

Baythroid® at 2.4-2.8 fl. oz. per acre. *Cucumber beetles only*. Do not exceed 11.2 fl. oz. or 4 applications per acre per season. Allow 7 days between applications. 0-day PHI. *RUP*.

Belay 2.13SC® at 3-4 fl. oz. per acre. Do not apply during bloom. 7-day PHI.

Brigade 2EC® at 2.6-6.4 fl. oz. per acre, or **Brigade WSB**® at 8-16 oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. 3-day PHI. *RUP*.

Danitol 2.4EC® at 10.67-16 fl. oz. per acre. *Cucumber beetles only*. Do not exceed 42.67 fl. oz. per acre per season. 7-day PHI. *RUP*.

Endosulfan 3EC® at 0.67-1.33 qts. per acre. *Pumpkins and winter squash only*. Do not exceed 4 applications per acre per season. Do not use after July 31, 2015. 11-day PHI.

Kryocide® at 8-16 lbs. per acre. Do not exceed 64 lbs. per acre per season. 7-day PHI for summer squash. 14-day PHI for all others.

Mustang MAX® at 2.8-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Apply a minimum of 4 gals. finished spray per acre by air, or 20 gals. finished spray per acre with ground equipment. Do not exceed 6.4 lbs. per acre. 0-day PHI. *RUP*.

Prokil Cryolite 50D® at 15-30.5 lbs. per acre. Do not exceed 153 lbs. per acre per season. 7-day PHI for summer squash. 14-day PHI for all others.

Sevin XLR PLUS® at 1 qt. per acre. *Not for squash vine borer*. When applied during hot, humid conditions, carbaryl may cause some phytotoxicity, especially on seedlings and newly set plants. Carbaryl may be highly toxic to bees visiting plants during bloom. Do not exceed 6 qts. per acre per season. 3-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. 1-day PHI. *RUP*.

Mites

Recommended Products

RR **Acramite 50WS**® at 0.75-1 lb. per acre. One application per season only. Do not apply less than 50 gals. of water per acre. 3-day PHI.

Agri-Mek 0.15 EC® at 8-16 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. Allow at least 7 days between applications. Do not make more than 2 sequential applications. Do not apply less than 20 gallons of water per acre. 7-day PHI.

Brigade 2EC® at 5.12-6.4 fl. oz. per acre. 3-day PHI.

Danitol 2.4EC® at 10.67-16 fl. oz. per acre. Do not exceed 42.67 fl. oz. per acre per season. 7-day PHI. *RUP*.

Dicofol 4E® at 1.25 pts. per acre. *Squash and cucumber only.* 2-day PHI.

Dimethoate 400® or **Dimethoate 4E**® at 1 pt. per acre. *Melons only*. 3-day PHI.

RR **Oberon 2SC**® at 7.0-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 7-day PHI.

Portal® at 2 pts. per acre. *Melons and cucumber only.* 3-day PHI for melons. 1-day PHI for cucumber.

Zeal® at 2-3 oz. per acre. 7-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Thrips

Recommended Products

Entrust® at 2-2.5 oz. per acre. Do not exceed 9 oz. per acre per season. 1-day PHI for cucumber. 3-day PHI for all others.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

Platinum® at 5-11 fl. oz. per acre. 30-day PHI.

Radiant SC® at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI for cucumber. 3-day PHI for all others.

Whiteflies

Recommended Products

Actara® at 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI.

Admire PRO® at 7-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. 21-day PHI.

Assail 30SG® at 2.5-5.3 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.

Brigade 2EC® at 5.2-6.4 fl. oz. per acre, or **Brigade WSB**® at 12.8-16.0 oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. 3-day PHI. *RUP*.

Closer 2SC® at 4.25-4.5 fl. oz. per acre. 1-day PHI.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

Fulfill® at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 0-day PHI.

M-Pede® at 1-2% by volume. Must contact whiteflies to be effective. 0-day PHI.

Neemix® according to label directions. 0-day PHI.

Oberon 2SC® at 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 7-day PHI.

Platinum® at 5-11 fl. oz. per acre. 30-day PHI.

Venom® at 1-4 oz. per acre. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Applying an insecticide to manage squash bugs is warranted in the early season when wilting is present, and at early flowering when more than one egg mass per plant is observed.

Fruiting Vegetables

Transplants

Eggplant, peppers, and tomatoes are typically started as transplants in greenhouses or artificially lit growing rooms — refer to Transplant Production, page 20.

For rapid seed germination, maintain the temperature of potting mix at 85°F. Grow eggplant seedlings between 70°F and 80°F during the day and 65°F and 70°F at night, and tomatoes and peppers between 65°F and 75°F during the day and 60°F and 65°F at night.

Pepper and eggplant seedlings should be ready for the field in six to eight weeks and tomatoes in five to seven weeks.

Before transplanting, harden seedlings by exposing them for a few days to higher light and temperatures between 60°F and 65°F. Set tomatoes in the field after the danger of frost has passed. For peppers and eggplant, wait until soil has warmed and average daily temperature reach 65°F.

Production Systems for Fresh Market

Fresh market eggplant, peppers, and tomatoes are often grown on raised beds covered with plastic mulch to promote earliness — see Using Plastic Mulch, page 24. Drip irrigation beneath the mulch provides a uniform water supply and can deliver fertilizer during the growing season. Typical beds are 30 inches across, 4 to 6 inches high, and centered 5 to 6 feet apart.

Tomatoes and eggplant: Space 1.5 to 2.5 feet apart in the row.

Peppers: Space 1 to 1.5 feet apart. Or, plant a double row of peppers with 1.5 feet between rows and 1 foot between plants.

Bare ground culture: Space rows 2.5 to 5 feet apart. *Tomatoes and eggplants:* space 1.5 to 3 feet apart in the row. *Peppers:* space 1 to 1.5 feet apart in the row.

Tomatoes may be left to grow over the ground or may be supported by cages, stakes, strings, or a trellis-weave system. Supported tomatoes produce higher quality fruit than unsupported plants and marketable yield is usually much greater. Tomatoes supported by stakes or trellises are sometimes pruned, which involves removing several or all of the branches up to the branch just below the first flower cluster when the branches are a few inches long. For tomatoes supported by vertical string, only one or two stems are allowed to grow and so pruning continues throughout the season to remove branches that develop above the first flower cluster. Pruned plants produce larger fruit than unpruned plants, but the quantity of fruit is reduced.

Peppers and eggplant may benefit from staking if plants tend to break, lean, or lodge. If peppers are in a double row on a bed, a row of short stakes strung with twine along the outside of each row will support the plants. Peppers and eggplant may also be supported using a trellis-weave system.

Production Systems for Processing Tomatoes

Select row spacing and bed formation that will work with available harvesting equipment. Double rows 16 to 20 inches apart on 5 to 6 feet centers are common, with plants 1 to 2 feet apart in the row.

Ethephon applications accelerate and concentrate fruit ripening, thus facilitating once-over machine harvesting of processing tomatoes.

For Machine Harvest: Apply 3.25 pts. Ethrel® or Cepha® in 5 to 70 gallons of water per acre as a spray over the entire plant when 10 to 30 percent of fruits are ripe. Harvest 15 to 21 days after treatment for optimum ripe fruit accumulation.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.8.

Fresh Market Eggplant, Peppers, and Tomatoes: Before planting, apply 30 pounds N per acre, 0 to 240 pounds per acre P_2O_5, and 0 to 300 pounds K_2O per acre based on soil test results and recommendations from your state. At transplanting, apply a starter solution containing N and P. If the transplant flat received a heavy fertilizer feeding just prior to setting, eliminate the starter solution. Three to four weeks after transplanting, and then six to eight weeks after transplanting, apply 30 to 40 pounds N per acre as a sidedressing. Sidedressing may be replaced by supplying N through the drip irrigation system at about 1 pound N per acre per day. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3 percent organic matter. The total

amount of N from fertilizer (including starter) and other credits should be 100 to 120 pounds per acre. K_2O may also be supplied through drip irrigation at a rate of 1 to 1.5 pounds per acre per day for peppers and eggplant, and 1.5 to 2.5 pounds per acre per day for tomatoes. Reduce the amount of K_2O applied before planting by the amount that will be supplied through drip irrigation.

Processing Tomatoes: Before planting, apply 40 pounds N per acre, and P_2O_5 and K_2O based on soil test results and recommendations from your state. At transplanting, apply a starter solution containing N and P. Four to five weeks after transplanting or after first fruit, set sidedress with 40 to 50 pounds N per acre. Reduce the amount of fertilizer N applied by the amount of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3 percent organic matter. The total amount of N from fertilizer (including starter) and other credits should be 80 to 100 pounds per acre.

Calcium: Tomatoes and peppers are susceptible to calcium deficiency even when adequate calcium levels are present in the soil. Deficiency results in a disorder called "blossom end rot." It often occurs under conditions of inadequate or excessive watering and/or excessive N fertilization with an ammonium source. Where the soil pH has been adjusted to 6.0 or higher, additional soil-applied calcium does not correct the disorder.

Environmental Factors

There are a number of tomato problems related to environmental and nutrient factors. Photos of the problems described below are provided on pages 207-210.

Sunscald: Fruit exposed to the sun may overheat and develop sunscald. The affected area turns white and does not ripen. The tissue may shrivel and sink in. It is most common when foliage does not shade fruit exposed to hot afternoon sun. Damage is usually confined to the area of the fruit with greatest exposure to the sun. Tomato variety, mineral nutrition, staking and pruning methods, and disease pressure can all influence the amount of foliage cover. This disorder also is observed on peppers and fruit of other vegetable crops.

Radial and concentric cracks: Rapidly growing fruit and fruit exposed to the sun tend to crack more readily. Cracking is more severe under hot, dry conditions followed by rainfall. To defend against growth cracks, select crack-resistant cultivars and carefully manage water availability (through irrigation management and the use of plastic mulch).

Zipper scars: These may be caused when the blossom sticks to the developing fruit. Zipper scars are especially common during cool weather. To avoid this problem, select resistant varieties and maintain proper greenhouse temperatures.

Catfacing: Flower buds that have been exposed to cold temperatures very early in development have shown a higher proportion of catfaced fruit. Large-fruited varieties tend to be more susceptible to this disorder. In some heirloom varieties, nearly all fruit is catfaced so it does not detract from the fruit's marketability. Variety selection is the most practical way to limit this problem. Exposure to some herbicides (2, 4-D or dicamba) can lead to similar fruit deformation.

Micro-cracks or rain checks: Very small cracks in the epidermis (called micro-cracks or rain checks) sometimes develop on fruit shoulders under highly humid conditions. Rain check is often more severe on fruit that has been exposed due to poor leaf cover. To minimize the problem, maintain healthy foliage and select varieties with good foliage cover.

Fruiting Vegetables — Eggplant

Varieties	Season	Comments
Dusky	extra-early	Good, but low yielding because of small fruit size
Classic	early	Long, slim, tapered
Epic	early	Oval
Ichiban	early	Long, slender
Little Fingers	early	Small, slender, borne in clusters
Millionaire	early	Slender, black, purple calyx
Kiko	early main	Holds color in fall
Nadia	main	Oval, long
Caspar	main	White, cylindrical
Ghostbuster	main	White, oval
Rosita	main	Lavender, long, cylindrical

Disease Control for Eggplant

Anthracnose

Use disease-free seed and/or transplants. Practice a 3-4 year crop rotation.

Recommended Products

Cabrio EG® at 8-12 oz. per acre. 0-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. 3-day PHI.

RR **Fontelis**® at 24 fl oz per acre. *Suppression only*. See label for greenhouse uses. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

RR **Quadris Flowable**® at 6.0-15.5 fl. oz. per acre. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. 0-day PHI.

Blossom End Rot

Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

Phytophthora Crown Rot

Follow a 4-year rotation with crops outside the tomato/pepper/eggplant and cucurbit families. Choose fields with well-drained soil and avoid low spots Use raised beds to promote drainage. Do not use irrigation water from a pond that collects runoff from fields infested with Phytophthora. Fungicides are not fully effective against this disease.

Recommended Products

Forum® at 6 oz. per acre. *Suppression only*. 0-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. Must be tank mixed with a product of a different mode of action. 2-day PHI.

Ranman® at 2.75 fl. oz. per acre. Alternate applications of Ranman® with fungicides that have a different mode of action. 0-day PHI.

Revus 2.09SC® at 8 fl. oz. per acre. 1-day PHI.

Ridomil Gold SL® treat soil at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. 7-day PHI.

Southern Blight

This disease is normally observed in southern climates or during seasons with above normal temperatures. Crop rotations with small grains and deep plowing crop residue should help to reduce inoculum.

Verticillium Wilt

Avoid fields with a history of Verticillium wilt. Rotate with small grains where possible.

Use of long rotations out of pepper/tomato/eggplant crops will prevent rapid increase of pathogen populations. Consider resistant (such as Irene) or partially resistant varieties.

Recommended Products

Fumigate with **Vapam**® at 37.5-75 gals. per acre under plastic mulch. Allow at least 21 days between application of fumigant and transplanting. Observe the 48-hour REI. See label for important application instructions.

White Mold

Avoid fields with history of the problem. Pathogen has large host range.

Recommended Products

BP **Contans WG**® at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.

Weed Control for Eggplant

The fruiting vegetables are warm-season crops nearly always started as transplants. When growers transplant crops onto black or other opaque plastic mulch, they sometimes use herbicides underneath the mulch, depending on the weed pressure and labor available to pull weeds by hand. Weeds between beds are typically controlled with cultivation, hand hoeing, herbicides, or a combination of the three. Weeds along the edge of the plastic mulch can be a particular challenge for cultivation equipment, and shielded or directed herbicide applications can help with control there.

Fresh market crops are also grown without plastic mulch, and similar weed control measures are used. Organic mulches (such as straw) can also provide good weed control in and between rows if applied in a thick enough mat before weeds emerge.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Wait at least 3 days before transplanting. Remove herbicide residue from plastic mulch prior to transplanting. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Burndown or Directed/Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

Preemergence Broadleaves and Grasses

Recommended Products

Trifluralin® products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. May cause early stunting if growing conditions are unfavorable, especially on eggplant. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gallon of transplant water.

Preemergence Broadleaves

Recommended Products

Sandea® at 0.5-1 oz. per acre. Apply between rows of crop, avoiding contact with crop. Avoid contact with surface of plastic mulch if present. Also controls nutsedge. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

Preemergence Grasses

Recommended Produ cts

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. Apply 4-6 weeks after transplanting when growing conditions favor good plant growth. May be applied over the top of transplants.

Postemergence Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L®. See details above for Burndown or Directed/Shielded Applications.

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim® see details above for Burndown or Directed/ Shielded Applications.

Sandea® see details above for Preemergence. Also controls nutsedge.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-32 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-16 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. 20-day PHI.

Spray on actively growing grass. Wait at least 14 days between applications.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 20-day PHI.

Insect Control for Eggplant

For combined insect control options in fruiting vegetables, see page 133.

Fruiting Vegetables — Pepper

Varieties	Season	Fruit Shape	Color[1]	DisTol/Res[2]	Comments
Alliance	mid-early	blocky, 3-4 lobes	G>R	BLS-1,2,3,4,5, CMV, PHY, PMV, PVY,	Large peppers
Archimedes	main	blocky, 3-4 lobes	G>R	BLS-1,2,3,7,8, PHY	
Aristotle X3R	main	blocky	G>R	BLS-1,2,3	Very consistent
Crusader	main	blocky	G>R	BLS-1,2,3, TMV, PVY, PMV, Stip	Dark green
Declaration	early-main	blocky 3-4 lobes	G>R	BLS-1,2,3,5, CMV,PHY	
Karisma	main	blocky 3-4 lobes	G>R	BLS-1,2,3, CMV,PMV,TMV,	
Lafayette	main	blocky	G>Y	BLS-1,2,3, PVY	Not for sandy soils
Paladin	early-main	long blocky	G>R	PHY	
PXX09941819	main	blocky, 3-4 lobes	G>R	BLB-1,2,3,4,5,	Large, blocky fruit
Revolution	main	blocky	G>R	BLS-1,2,3,5, CMV, PHY	Large peppers, not recommended for Iowa
Vanguard	main	blocky 4 lobe	G>R	CMV,PHY, BLS-1,2,3,4,5	

[1]Immature to ripe fruit color: G=green, R=red, Y=yellow
[2]Disease resistance or tolerance as reported by seed company. BLS-1,2,3=bacterial spot strains 1,2, and 3; CMV=cucumber mosaic virus; PHY=Phytophthora; PMV=pepper mottle virus; PVY=potato virus Y; TMV=tobacco mosaic virus.

Colored Bells for trial	Gold Finch (yellow), Orange Grande, Oriole (orange), Sweet Chocolate, Blackbird (brown to black), Blue Jay (lilac), Islander (lavender), Tequila (green to purple to red), Blushing Beauty (ivory to red)
Banana peppers/cubanelles	Sweet Banana (turns red at maturity), Key Largo (cubanelle, orange-red at maturity)
Sweet peppers	Aruba, Corno Verde, Giant Marconi
Hot Peppers	Hungarian Hot Wax: Stoked. Jalapeno: Tula, Grande, Ixtapa, Mitla, Pecos Long Thick Red: Ring of Fire, Copacabana (yellow) Anaheim: Big Chile, Anaheim TMR23

Disease Control for Pepper

Anthracnose

Use disease-free seed and/or transplants. Practice a 3-4 year crop rotation.

Recommended Products

Cabrio EG® at 8-12 oz. per acre. 0-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. Not all chlorothalonil formulations are labeled for pepper. 3-day PHI.

RR **Fontelis**® at 24 fl. oz. per acre. *Suppression only*. See label for greenhouse uses. 0-day PHI.

Manzate Pro-Stick® at 1.6-2.1 lbs. per acre. 7-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

RR **Quadris Flowable**® at 6.0-15.5 fl. oz. per acre. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. 0-day PHI.

Tanos® at 8 oz. per acre. 3-day PHI.

Bacterial Spot

Resistant varieties are available for bacterial spot. Note that several races of bacterial spot exist that can affect pepper.

Use disease-free seed and/or transplants. Consider seed treatment with hot water, HCL, or dilute Clorox. For more information, see Seed Treatments (page 23) or *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens* (Ohio State University Extension Fact Sheet HYG-3085-05), available from Ohioline, ohioline.osu.edu.

Copper Resistance: Strains of the bacterium that cause bacterial spot on tomato and pepper that are resistant to copper products have been reported in the Midwest. Using Actigard®, Agri-mycin 17®, Tanos®, and Serenade Max® as labeled may help manage copper-resistant strains.

Recommended Products

Actigard® at 0.3-0.75 oz. per acre. Use low rate early in season and increase with time. See label. *Chili pepper only*. Use up to 8 weekly applications. May be effective when used with other labeled pesticides. 14-day PHI.

Agri-mycin 17® at 200 ppm. Make one or two applications to seedlings, alternated with a fixed copper compound (see below) beginning at the two-leaf stage. Not labeled for use after transplanting.

Several formulations of **copper** products (e.g., Kocide®, Champ®, Cuprofix®) are labeled for greenhouse use at 1 tablespoon (TBSP) per 1,000 square feet rates. Repeat according to label directions. Carefully note re-entry and personal protection warnings.

Copper sprays in the field reduce the rate of bacterial spread. Avoid consecutive seasons with pepper or tomato in the same field. Avoid working in fields when plants are wet. Strains of copper-resistant bacteria causing bacterial spot have been found in the Midwest.

Serenade Max® at 1-3 lbs per acre. May help bacterial spot management when copper-resistant strains of the bacterium are present.

Tanos 50DF® at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank mix as described on the label.

Blossom end Rot

Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

Bacterial Canker

Bacterial canker can occur on pepper but is relatively rare. However, infected peppers can serve as a source of inoculum for bacterial canker of tomato. Use disease-free seed and transplants (see comments for bacterial spot management). Transplant facility treatments listed under bacterial spot will help reduce the severity of bacterial canker. However, copper applications in the field are generally ineffective for controlling canker.

Fields with a history of canker should be planted to crops other than tomato, potato, pepper, or eggplant for at least three years. Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach solution or another appropriate solution. Avoid working in wet fields.

Recommended Products

Tanos 50DF® at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank mix with copper and mancozeb products.

Phytophthora Blight

Avoid areas of fields where waterlogged root zones persist throughout the season. Pepper is very susceptible to this disease. Use well-drained fields. Planting on raised beds will increase soil drainage. Rotate infested fields with non-host crops for several years.

Use resistant varieties if available for commercial production. See Table 29, pages 68-69. Water management is of primary importance for Phytophthora control.

Timing is Critical: Fungicides applied for Phytophthora blight are most effective if applied when disease threatens, but before symptoms become severe.

Recommended Products

Agri-Fos 50WP®. See label for rate. 0-day PHI.

Forum® at 6 oz. per acre. *Suppression only*. 0-day PHI.

BP **Phostrol®** at 1-2 qts. per acre. 0-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.

Ranman® at 2.75 fl. oz. per acre. 0-day PHI.

Revus® at 8 fl. oz. per acre. 1-day PHI.

Ridomil Gold SL® soil treatment at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. *Phytophthora crown rot only*. Fungicides will not be effective if pepper is planted in poorly drained fields with a history of the disease. 7-day PHI.

Powdery Mildew

Recommended Products

Cabrio® at 8-16 oz. per acre. 0-day PHI.

RR **Quadris 2.08EC®** at 6-15.5 fl. oz. per acre. Apply at 7-14 day intervals. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. Make no more than 2 consecutive applications before switching to a product with a different mode of action. 0-day PHI.

RR **Quintec**® at 4-6 fl. oz. per acre. *Pepper only*. 3-day PHI.

Rally 40WSP® at 2.5-4.0 oz. 0-day PHI.

Southern Blight

This disease is normally observed in southern climates or during seasons with above normal temperatures. Crop rotations with small grains and deep plowing crop residue should help to reduce inoculum.

Recommended Products

Terraclor®. See label for rate. May be applied as a transplant solution or in-furrow.

Virus Diseases

Grow resistant varieties. Plant disease-free transplants. Eliminate broadleaf weeds within 150 feet of field before crops are established.

Some broadleaf weeds may be reservoirs for pepper viruses. Aphids may spread virus diseases from weeds to peppers and from diseased peppers to healthy peppers. Oil sprays timed with aphid flight periods may prevent virus transmission by aphids but have short-term residual effectiveness. Light-colored and reflective mulches may deter aphids from landing on plants and transmitting the virus.

White Mold

Avoid fields with history of the problem. Pathogen has large host range. Avoid tomato after tomato rotations.

Recommended Products

BP **Contans WG**® at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.

Weed Control for Pepper

The fruiting vegetables are warm-season crops nearly always started as transplants. When growers transplant crops onto black or other opaque plastic mulch, they sometimes use herbicides underneath the mulch, depending on the weed pressure and labor available to pull weeds by hand. Weeds between beds are typically controlled with cultivation, hand hoeing, herbicides, or a combination of the three. Weeds along the edge of the plastic mulch can be a particular challenge for cultivation equipment, and shielded or directed herbicide applications can help with control there.

Fresh market crops are also grown without plastic mulch, and similar weed control measures are used. Organic mulches (such as straw) can also provide good weed control in and between rows if applied in a thick enough mat before weeds emerge. Processing peppers are commonly grown in double rows on flat or raised beds. Weeds are controlled with a combination of herbicides and cultivation.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. 30-day PHI for tomato. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Wait at least 3 days before transplanting. Remove herbicide residue from plastic mulch prior to transplanting. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Burndown or Directed/Shielded Applications Broadleaves

Aim EC® at 0.5-2 fl. oz. per acre. Apply prior to transplanting or apply between crop rows with hooded sprayer. Do not apply before direct seeding. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at 0.67-2.67 pts. per acre. *Not for banana pepper except in Ohio*. Use lower rate on coarse soils, and higher rate on fine soils. Apply before transplanting. May cause temporary bleaching of crop leaves.

Devrinol 50DF® at 2-4 lbs. per acre. Use lower rate on coarse soil. Apply and incorporate before seeding or transplanting. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application.

Dual Magnum® at 0.5-1 pt. per acre. *Indiana and Ohio only.* Apply before transplanting and do not incorpo rate, or apply within 48 hours after transplanting. Reduce risk of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Do not exceed 1pt. per acre or 1 application per crop. 60-day PHI.

Prowl H2O® at 1-3 pts. per acre. *Not for use under plastic mulch*. Apply and incorporate before planting, apply before planting without incorporation, or apply to established transplants as a directed spray. Avoid any contact with leaves or stems of crop. 70-day PHI.

Trifluralin® products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. May cause early stunting if growing conditions are unfavorable. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gallon of transplant water.

Preemergence Broadleaves

Recommended Products

League® at 4-6.4 oz. per acre. Apply between rows. Avoid contact with crop and plastic mulch (if present). You may use a directed spray in bare ground culture if pepper plants are well-established and at least 10 inches tall. Directed spray must hit no more than 2 inches of pepper stem above ground and must not hit pepper fruit. If emerged weeds are present, include a Valent-recommended surfactant to control yellow nutsedge and labeled broadleaf weeds that are 1-3 inches tall. Use the higher rate in fields with a known history of nutsedge. Do not exceed 1 application and 6.4 oz. per acre per year. 21-day PHI.

Sandea® at 0.5-1 oz. per acre. Apply between rows of crop, avoiding contact with crop. Avoid contact with surface of plastic mulch if present. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Also controls nutsedge. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

Spartan Charge® at 4.5-7.6 fl. oz. per acre. *For use on peppers grown on plastic mulch in Ohio only.* Controls apple of Peru, ALS-resistant lambsquarters, and yellow nutsedge. Apply with directed, shielded sprayer. Before transplanting apply up to shoulders of plastic mulch covered bed, or after transplanting apply to row middles. Do not exceed 7.6 fl. oz. per acre per 12-month period.

Preemergence Grasses

Recommended Products

Prefar 4E® at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting.

Postemergence Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L®. See details above for Burndown or Directed/Shielded Applications.

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim®. See details above for Burndown or Directed/ Shielded Applications.

League®. See details above for Preemergence. Also controls nutsedge.

Sandea®. See details above for Preemergence. Also controls nutsedge.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-32 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-16 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. 20-day PHI.

Spray on actively growing grass. Wait at least 14 days between applications.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 20-day PHI.

Insect Control for Pepper

For combined insect control options in fruiting vegetables, see page 133.

Fruiting Vegetables — Tomato

Varieties	Season	Crack Resistance	Firmness	Vine Type[1]
Sunshine	first early	good	firm	D
Jet Star	early	good	fair	I
Celebrity	early-main	fair	fair	D
Fabulous	early-main	good	firm	D
Florida 91	early-main	excellent	firm	D
Mountain Spring	early-main	excellent	very firm	D
Red Sun	early-main	good	firm	D
Sun Brite	early-main	good		D
Sunsation	early-main		firm	D
Amelia	main	good	firm	D
BHN 589	main	excellent	firm	D
Big Beef	main	good	fair	I
Biltmore	main	good	firm	D
Crista	main	good	very firm	D
Florida 47	main	good	firm	D
Mountain Fresh	main	good	firm	D
Sun Leaper	main-late		firm	D
For trial: Primo Red (early), Linda, Tribute, HM8849, Mt. Glory, BHN 876				
Yellow: Carolina Gold, Lemon Boy. For trial: BHN 876.				
Cherry types: Mountain Belle				
Grape types: Santa (indeterminate), Sweet Olive (determinate), Jolly Elf (determinate, for trial), Golden Sweet (yellow)				
Roma types: BHN 411, Plum Dandy, LaRossa				

[1]Vine Type: I=indeterminate (long vine); D=determinate (short vine).

Disease Control for Tomato

Anthracnose

Symptoms usually occur on ripe or over-ripe fruit.

Winter/Off-season: Rotate crops at least 2-3 years and practice fall tillage.

Fruit Set: Begin fungicide applications at or shortly before fruit set.

Harvest: Inspect fruit for lesions.

Recommended Products

Cabrio EG® at 8-12 oz. per acre. See label to avoid practices that could result in crop injury. 0-day PHI.

Bravo®, **Echo**®, and **Equus**® formulations are labeled for use at various rates. 0-day PHI.

Dithane®, **Manzate**®, and **Penncozeb**® formulations are labeled at various rates. 5-day PHI.

Fontelis® at 24 fl. oz. per acre. *Suppression only*. See label for greenhouse uses. 0-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small fruit such as cherry tomato. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

RR **Quadris Flowable**® at 5-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8 fl. oz. per acre. 0 -day PHI.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. Use when late blight is also a concern. 1-day PHI.

Tanos® at 8 oz. per acre. 3-day PHI.

Bacterial Canker

The bacterium becomes systemic in the plant causing wilt and leaf/fruit/stem lesions.

RR This is a reduced-risk pesticide. See page 34 for details.

Use disease-free seed and transplants. The transplant facility treatments listed for Bacterial Spot/Speck (below) will help reduce the severity of bacterial canker. However, copper applications in the field are generally ineffective for controlling canker.

Fields with a history of canker should be planted to crops other than tomato, potato, pepper, or eggplant for at least 3 years. Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach solution or another appropriate solution. Avoid working in wet fields.

Winter/off-season: Rotate crops at least 3 years and practice fall tillage. May be seedborne. Consider seed treatment with hot water, HCL, or dilute Clorox. For more information, see Seed Treatments (page 23) or *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens* (Ohio State University Extension Fact Sheet HYG-3085-05), available from Ohioline, ohioline.osu.edu.

Greenhouse: Inspect seedlings for disease and apply one or two fixed copper product applications. Tank mix copper product with mancozeb (see bacterial spot/speck below).

Planting: Do not plant seedlings that have symptoms of bacterial canker.

Fruit Set: Inspect plants for symptoms of bacterial canker.

Harvest: Inspect fruit. Avoid saving seed.

Recommended Products

Tanos 50DF® at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank mix with copper and mancozeb products.

Bacterial Spot/Speck

Lesions of this disease can be found on leaves, stems, and fruit. Use disease-free seed and/or transplants.

Copper Resistance: Strains of the bacterium that cause bacterial spot on tomato that are resistant to copper products have been reported in the Midwest. Actigard®, Agri-mycin 17®, mancozeb products, Tanos®, and Serenade Max® as labeled may help manage copper-resistant strains.

Winter/Off-season: Rotate crops at least 2 years and practice fall tillage. Purchase seed tested for these diseases.

Greenhouse: Scout and apply fixed copper if disease threatens.

Planting: Do not plant seedlings with symptoms of bacterial spot/speck. Apply fixed copper product tank mixed with mancozeb on 7-10 day schedule, depending on disease pressure, beginning within 1 week after transplanting.

Harvest: Inspect fruit. Avoid saving seed.

Recommended Products

Actigard® at 0.3-0.75 oz. per acre. 14-day PHI.

Agri-mycin 17® or **Harbour**® at 200 ppm. Apply one or two times to seedlings, alternated with a fixed copper compound (see below) beginning at the two-leaf stage. Not labeled for use after transplanting.

Several formulations of copper products (Badge®, Champ®, Cueva®, Cuprofix®, Kentan®, Kocide®, Nordox®) are labeled for greenhouse use. Apply according to label directions.

Copper sprays in the field reduce the rate of bacterial spread. Avoid consecutive seasons with pepper or tomato in the same field. Avoid working in fields when plants are wet. Strains of the bacteria that cause bacterial spot that are copper-resistant have been found in the Midwest. Mancozeb products (e.g., Dithane®, Manzate®, and Penncozeb®) when applied with copper products, allow more copper to become available, so may help manage copper-resistant bacterial spot strains.

Serenade Max® at 1-3 lbs. per acre. Alternate with copper products. May help bacterial spot management when copper-resistant strains of the bacterium are present.

Tanos 50DF® at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank mix with copper and mancozeb products.

Blossom End Rot

Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

May be acceptable for use in certified organic production. Check with your certifier before use.

Botrytis Gray Mold

This disease is observed primarily in greenhouses and high tunnels were it causes dieback of tomato leaves and lesions on fruit.

Winter/Off-season: Rotate crops at least 2-3 years and practice fall tillage. Keep up plant's calcium levels.

Greenhouse/High tunnel: Keep temperatures higher than 70°F, and maintain relative humidity less than 90%. Keep plants well pruned to improve air circulation.

Planting: Begin protective fungicide applications.

Harvest: Inspect fruit for symptoms.

Recommended Products

Botran 75W® at 1 lb. per 100 gals. of water. Labeled for the stem phase of gray mold. Apply to stems up to a height of 24 inches. Seedlings may be injured. Available for greenhouse use.

Several **chlorothalonil** formulations (e.g., Bravo®, Echo®, Equus®) are available at various rates. *Field use only*. 0-day PHI.

Cabrio® at 8-16 oz. per acre. *Suppression only*. 0-day PHI.

RR **Endura**® at 9-12.5 oz. per acre. 0-day PHI.

RR **Fontelis**® at 16-24 fl. oz. per acre. See label for greenhouse uses. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

Scala® at 7 fl. oz. per acre. May be used in greenhouses (see label for cautions). 1-day PHI.

Switch 62.5WB® at 11-14 oz. per acre. 0-day PHI.

Buckeye Rot and Phytophthora Blight

These diseases are favored by heavy rains and waterlogged soils. Symptoms include discolored fruit and declining plants.

Rotate away from tomato, pepper, vine crops, or snap beans for 3 years. Avoid low areas of fields. Plastic mulch may reduce splash infection.

Winter/Off-season: Rotate crops at least every 3 years and practice fall tillage. Avoid poorly drained soils. Use raised beds. Mulch may lessen buckeye rot's impact.

Planting: Consider fungicide drench. Regular fungicide schedule may lessen impact of buckeye rot.

Recommended Products

RR **Gavel 75DF**® at 1.5-2 lbs. per acre. 5-day PHI.

RR **Quadris 2.08EC**® at 5.0-6.0 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.6 pts. per acre. 0-day PHI.

Tanos® at 8 oz. per acre. *Suppression only*. Must be tank mixed. 3-day PHI.

Early Blight and Septoria Leaf Blight

Both of these diseases initially cause lesions on lower leaves of the tomato plant. Plant resistant varieties. Use wilt resistant "VF" cultivars, and avoid fields with a wilt history. Tomato plants weakened by wilt disease may be more prone to leaf blights. Practice 3-4-year rotation with unrelated crops. Rotate out of fields with a history of early blight or Septoria leaf spot.

Group 11 Resistance: Strains of the fungus that causes early blight that are resistant to group 11 fungicides have been observed in Indiana. Group 11 products labeled for tomato and early blight include Cabrio® and Quadris®. Tank mix group 11 fungicides with products that have a different mode of action, or alternate group 11 fungicides with fungicides that have a different group number. See Table 32 (page 72) for more information.

Winter/Off-season: Use crop rotations of at least 2-3 years for Septoria and 3-4 years for early blight.

Planting: Begin protective fungicide applications on a 7-14 day schedule.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled at various rates. 0-day PHI.

Cabrio EG® at 8-12 oz. per acre. 0-day PHI.

Dithane®, **Mancozeb**®, and **Penncozeb**® are labeled at various rates. 5-day PHI.

RR **Endura 70WG**® at 2.5-3.5 oz. per acre. *Early blight only*. 0-day PHI.

RR **Fontelis**® at 16-24 fl. oz. per acre. See label for greenhouse uses. 0-day PHI.

RR **Gavel 75DF**® at 1.5-2 lbs. per acre. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

OSO 5%EC® at 3.7-13 fl. oz. per acre. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

RR **Quadris 2.08EC**® at 5.0-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.3-1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. *Septoria suppression only.* 14-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 1-day PHI.

Scala® at 7 fl. oz. per acre. *Early blight only*. Use only in a tank mix with another fungicide effective against early blight. May be used in greenhouses (see label for cautions). 1-day PHI.

Switch 62.5WB® at 11-14 oz. per acre. *Early blight only*. Do not apply to small-fruited varieties in the greenhouse. 0-day PHI.

Tanos® at the following rates:

Early blight: 6-8 oz. per acre.

Septoria: 8 oz. per acre.

See comments above for Anthracnose.

Ziram 76DF® at 3-4.0 lbs. per acre. *Not for cherry tomato*. Use with effective spreader-sticker. 7-day PHI.

Fusarium Crown and Root Rot

Use long crop rotations. Steam or fumigate soil in the greenhouse prior to transplanting.

Fusarium Wilt

Plant resistant varieties. Avoid fields with a history of root knot nematode.

Late Blight

The fungus that causes late blight does not overwinter in the Midwest. Thus, the fungus must be transported into the Midwest before the disease affects tomatoes.

Winter/Off season: Destroy cull plies and disk under tomato fields at the end of each season.

Planting: Apply specialized fungicides when late blight threatens.

Harvest: Inspect fruit for symptoms of late blight.

Recommended Products

BP **Agri-Fos 50WP**®. See label for rate. 0-day PHI

Chlorothalonil and **mancozeb** products may be used. Higher rates may be required for late blight control. 0-day PHI for chlorothalonil. 5-day PHI for mancozeb. Best used in tank mixes with other products listed here.

Curzate® at 3.2-5 oz. per acre. Apply Curzate® plus a contact (protectant) fungicide. Use the 5 oz. rate if late blight is present. 3-day PHI.

RR **Gavel 75DF**® at 1.5-2 lbs. per acre. 5-day PHI.

Previcur Flex® at 0.7-1.5 pts. per acre. See label for greenhouse instructions. 5-day PHI.

Presidio® at 3-4 fl. oz. per acre. 2-day PHI.

Priaxor® at 8 fl. oz. per acre. *Suppression only*. 0-day PHI.

Prophyt®. See label for rate. 0-day PHI.

RR **Ranman 400SC**® at 2.1-2.75 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. 14-day PHI.

Revus® at 5.5-8 fl. oz. per acre. *Suppression only*. 1-day PHI.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 1-day PHI.

Ridomil Gold Bravo SC® at 2.5 pt. per acre. Use only when late blight strains in the area are known to be sensitive to Ridomil®. Tank mix with a penetrating surfactant. Do not use a sticker. 5-day PHI.

Tanos 50WP® at 8 oz. per acre. Tank mix with a contact fungicide with a different mode of action. 3-day PHI.

Zampro® at 14 fl. oz. per acre. 4-day PHI.

Leaf Mold

This disease causes yellow lesions on the upper side of the tomato leaf. It is common in greenhouse and high tunnel tomatoes but is uncommon in open field tomatoes.

Winter/Off-season: Rotate crops at least 2-3 years and practice fall tillage. Use sanitation in greenhouse tomatoes.

Greenhouse: Scout for disease. Apply fungicide labeled for greenhouse if necessary.

Planting: Control relative humidity in the greenhouse by venting and pruning. Labeled fungicides may help control leaf mold.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are available at various rates. *Field use only*. 0-day PHI.

Some **copper** formulations are labeled and may be organically certified. Some formulations may be labeled for the greenhouse.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled at various rates. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

Quadris Top® at 8 fl. oz. per acre. 0-day PHI.

Tanos® at 8 oz. per acre. 3-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Powdery Mildew

Recommended Products

Cabrio® at 8-16 oz. per acre. 0-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

RR **Quadris 2.08EC**® at 5.0-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. 0-day PHI.

Rally 40WSP® at 2.5-4.0 oz. 0-day PHI.

Switch® at 11 oz. per acre. *Not for small-fruited varieties in the greenhouse.* 0-day PHI.

Southern Blight

This disease is normally observed in southern climates or during seasons with above normal temperatures.

Crop rotations with small grains and deep plowing crop residue should help to reduce inoculum.

Tobacco Mosaic Virus

This disease is more of a problem in fresh market tomatoes than processing tomatoes due to extensive handling. The best control is to use a resistant cultivar. There is no chemical control. If only a few plants are showing symptoms, remove them carefully so as not to touch other plants. Control weeds around fields, because some weeds are known to harbor the virus.

Tomato Spotted Wilt Virus

This virus is carried by thrips and can cause major loss to tomatoes if it infects young plants. If southern-grown transplants are used, growers should be certain that they are from inspected, disease-free fields. Northern-grown transplants should be grown in isolation from ornamental plants. Controlling thrips may slow the spread of the virus in greenhouse and field.

Verticillium Wilt

Many tomato cultivars have host resistance to Verticillium wilt. Avoid fields with a history of Verticillium wilt. Rotate with small grains where possible. Use of long rotations out of solanaceous crops will prevent rapid increase of pathogen populations. Tomato varieties with resistance are available.

Recommended Products

Fumigate with **Vapam**® at 37.5-75 gals. per acre under plastic mulch. *Not for greenhouse use.* Allow at least 21 days between application of fumigant and transplanting. Observe the 48-hour REI. See label for important application instructions.

White Mold (Timber Rot)

This disease may be more common in greenhouses and high tunnels than in open fields. The fungus that causes this disease is soilborne and often results in a woody appearance of the lower stem of the tomato plant. Avoid fields with history of the problem. Pathogen has large host range. Avoid tomato after tomato rotations.

Winter/Off-season: Use long rotations with corn or small grains. Growers should avoid rotations with tomato, pepper, potato, and snap bean.

Greenhouse/Planting: White mold may be common where tomato is grown yearly in the same soil such as under a greenhouse structure.

Fruit Set: Inspect plants for symptoms of white mold.

Recommended Products

Cabrio EG® at 12-16 oz. per acre. *Suppression only. Not for greenhouse or high tunnel use.* 0-day PHI.

BP **Contans WG**® at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.

Priaxor® at 4-8 fl. oz. per acre. *Suppression only. Not for greenhouse use.* 0-day PHI.

Typical fresh market tomato production in the Midwest includes plants that are tied to stakes with twine using the Florida weave, raised beds, and plastic mulch.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Product/Disease Ratings for All Fruiting Vegetables[1]

Product (REI/PHI)[2]	**Common Name** MOA or FRAC code: fungicides with a number as the MOA code should be tank mixed or alternated with a different MOA code according to the label.	Anthracnose (tomato)	Anthracnose (pepper)	Bacterial Canker	Bacterial Spot/Speck	Botrytis Gray Mold	Buckeye Rot	Early Blight	Septoria Leaf Blight	Late Blight (tomato)	Phytophthora Blight (pepper)	Leaf Mold	White Mold	Comments
Actigard® (12/24)	acibenzolar (P)				F									Not for bell pepper. Do not apply to stressed plants.
Agri-Mycin 17®, Ag Streptomycin®	streptomycin sulfate (25)				F									For use on tomato/pepper seedlings produced for transplanting only.
Botran® (12/10)	2, 6-dichloro-4-nitroanaline (29)					G								Application to seedlings may result in injury.
Bravo®, Echo®, Equus® (12/0)	chlorothalonil (M)	G	G			F	F	F	G	VG		F		Effective against a wide range of fungal diseases. Not for greenhouse use.
Cabrio® (12/0)	pyraclostrobin (11)	G	VG			F		VG	VG	P				
Contans WG® (4/NA)	CON/M/91-08 (NA)												F	Apply with conventional spray equipment directly to soil surface.
copper (many trade names) (24/0)	copper (M)	F	F	P	F	P		F	F	F		F		Tank mix with mancozeb products to overcome copper resistance in bacterial spot strains.
Curzate 60DF® (12/3)	cymoxanil (27)									VG				Translaminar systemic activity against tomato late blight.
Dithane®, Manzate®, Penncozeb® (24/5)	mancozeb (M)	F				P	F	G	G	F		F		
Endura® (3/9)	boscalid (7)					VG		VG						Increase spray volumes as plants grow.
Fontelis® (12/0)	penthiopyrad (7)	S				G		VG	VG					
Gavel® (48/5)	mancozeb (M), zoxamide (22)						F	G	G	F		F		May be used with copper products to manage bacterial spot.
Inspire Super® (12/0)	difenconazole (3), cyprodinil (9)	F						G	G			G		
Presidio® (12/2)	fluopicolide (43)									VG	G			
Previcur Flex® (12/5)	propamocarb hydrochloride (28)									VG				
Priaxor® (12/0)	fluxapyroxad (7), pyraclostrobin (11)	G	G			F		G	G					
Quadris® (4/0)	azoxystrobin (11)	G	VG				P	VG	VG	P				
Quadris Top® (12/0)	azoxystrobin (11), difenconazole (3)	G	VG					VG	VG					
Ranman® (12/0)	cyazofamid (21)									VG	G			
Reason® (12/14)	fenamidone (11)							VG	VG	S	S			
Revus Top® (12/1)	difenconazole (3), mandipromid (40)	G						G	G	G	F	G		
Ridomil Gold GR®, Ridomil Gold SL® (48/7)	mefanoxam (4)						G			VG*	G*			*Effective against sensitive isolates only.
Scala® (12/1)	pyrimethanil (9)					G		G						Label includes greenhouse instructions.
Switch® (12/0)	cyprodinil (9), fludioxanil (12)					G		G						Do not apply to cherry or grape tomatoes in the greenhouse.
Tanos® (12/3)	cymoxanil (27), famoxadone (11)	F	G	S	S		S	G	G	G		G		Tank mix with manzate or other EBDC.
Zampro® (12/4)	amitoctradin (45), dimethomorph (40)									VG	P			

[1]Fungicide rating code-VG=very good. G=good. F=fair. P=poor. S=suppression only. Based on research and experience of the authors.
[2]REI (re-entry interval) in hours: do not enter or allow workers to enter areas treated during the REI period. PHI (pre-harvest interval) in days: the minimum time that must pass between the last pesticide application and crop harvest.

Weed Control for Tomato

The fruiting vegetables are warm-season crops nearly always started as transplants. When growers transplant crops onto black or other opaque plastic mulch, they sometimes use herbicides underneath the mulch, depending on the weed pressure and labor available to pull weeds by hand. Weeds between beds are typically controlled with cultivation, hand hoeing, herbicides, or a combination of the three. Weeds along the edge of the plastic mulch can be a particular challenge for cultivation equipment, and shielded or directed herbicide applications can help with control there.

Fresh market crops are also grown without plastic mulch, and similar weed control measures are used. Organic mulches (such as straw) can also provide good weed control in and between rows if applied in a thick enough mat before weeds emerge. Processing tomatoes are commonly grown in double rows on flat or raised beds. Weeds are controlled with a combination of herbicides and cultivation.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Remove herbicide residue from plastic mulch prior to transplanting. Do not use row-middle applications for tomatoes grown on sandy soils because crop injury may occur. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Gramoxone Inteon 2L® at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. 30-day PHI for tomato. *RUP*.

Burndown or Directed/Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply prior to transplanting, or apply between crop rows with hooded sprayer. Do not apply before direct seeding. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

Preemergence Broadleaves and Grasses

Recommended Products

Devrinol 50DF® at 2-4 lbs. per acre. Use lower rate on coarse soil. Apply and incorporate before seeding or transplanting. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application.

Dual Magnum® at 1-2 pts. per acre. Use lower rate on coarse soils. Apply prior to transplanting, or as a directed spray after transplanting. Crop injury may occur under unfavorable growing conditions. Not recommended for fresh market tomatoes. 30- to 90-day PHI depending on rate.

Matrix 25DF® at 1-2 oz. per acre. Use 0.5 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply when weeds are less than 1 inch tall. Soil activity requires rainfall within 5 days of application. If crop is stressed, chlorosis may occur. Do not exceed 4 oz. per acre per year. 45-day PHI.

Prowl H2O® at 1-3 pts. per acre. *Not for use under plastic mulch*. Apply and incorporate before planting, apply before planting without incorporation, or apply to established transplants as a directed spray. Avoid any contact with leaves or stems of crop. 70-day PHI.

Trifluralin® products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. May cause early stunting if growing conditions are unfavorable. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gal. of transplant water.

Preemergence Broadleaves

Recommended Products

League® at 4-6.4 oz. per acre. Apply 1 day or more before transplanting to weed-free transplant beds. For plastic culture, apply after final tillage just before installing plastic mulch. If no preplant application is made in bare ground culture, apply post-transplant over-the-top from 3-5 days after transplanting through the early bloom stage, or apply a directed spray covering soil from crop row to row middles after transplants are well established. If emerged weeds are present use a Valent-recommended surfactant to control labeled weeds 1-3 inches tall. Controls yellow nutsedge and several annual broadleaf weeds. Use the higher rate in fields with a known history of nutsedge. Do not exceed 1 application and 6.4 oz. per acre per year. 21-day PHI.

Sandea® at 0.5-1 oz. per acre. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply to soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait 7 days after application and laying mulch before transplanting. Or apply between rows of crop, avoiding contact with crop and surface of plastic mulch, if present. For tomatoes on bare ground only, apply over the top of well-established, actively growing plants no sooner than 14 days after transplanting and before first bloom. Also controls nutsedge. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

Sencor 4F® at 0.5-1 pt. per acre, or **Sencor 75DF**® at 0.33-0.66 lb. per acre. Broadcast and incorporate before transplanting, or broadcast after transplants are established. Or, use Sencor 4F® at up to 2 pts. per acre, or Sencor 75DF® at 1.33 lbs. per acre and apply a directed spray between crop rows after transplants are established. May be applied preplant incorporated with trifluralin products for improved weed control. Crop injury may occur if applied over the top of plants within 3 days of cool, wet, or cloudy weather. Wait at least 14 days between applications. Do not exceed 2 pts. of Sencor 4F®, or 1.33 lbs. of Sencor 75DF® per acre per season. 7-day PHI.

Spartan 4F at 2.25 to 8 fl. oz. per acre. Apply before transplanting as a broadcast or banded application. Will also control nutsedge. Do not use on soils classified as sand, which have less than 1% organic matter. Maximum per acre per 12 months is 12 oz.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. Apply 4-6 weeks after transplanting when growing conditions favor good plant growth. May be applied over the top of transplants.

Postemergence Broadleaves and Grasses

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Gramoxone Inteon 2L®. See details above for Burndown or Directed/Shielded Applications.

Matrix 25DF® See details above for Preemergence.

Postemergence Broadleaves

Recommended Products

League®. See details above for Preemergence. Also controls nutsedge.

Sandea®. See details above for Preemergence. Also controls nutsedge.

Sencor®. See details above for Preemergence.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-32 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-16 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. 20-day PHI.

Spray on actively growing grass. Wait at least 14 days between applications.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 20-day PHI.

Insect Control for Tomato

For combined insect control options in fruiting vegetables, see page 133.

Herbicides for All Fruiting Vegetables[1]

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop[2]				Timing Relative to Weeds		Weed Groups Controlled			Crops[3]		
		Before Transplanting	After Transplanting, between rows only	Postemergence	Incorporated	Preemergence	Postemergence	Annual Grasses	Small-seeded Broadleaves	Broadleaves	Tomato	Pepper	Eggplant
Aim EC® (12h/-)	carfentrazone	X	X				X		X	X	X	X	X
Command 3ME® (12h/-)	clomazone	X				X		X	X	X		X	
Dacthal W-75®, Dacthal Flowable® (12h/-)	DCPA			X		X		X			X		X
Devrinol 50DF® (12h)	napropamide	X			Yes	X		X	X		X	X	X
Dual Magnum® (24h/30-90d)	s-metolachlor	X	X			X		X	X		X	X	
Gramoxone Inteon 2L® (12h to 24h)	paraquat	X	X				X	X	X	X	X	X	X
League® (12h/21d)	imazosulfuron	X	X	X		X	X		X	X	X	X	
Matrix® (4h/ 45d)	rimsulfuron	X		X		X	X	X	X	X	X		
Poast® (12h/20d)	sethoxydim			X			X	X			X	X	X
Prefar 4E® (12h/-)	bensulide	X			Yes	X		X				X	
Prowl H_2O® (12h/70d)	pendimethalin	X	X			X		X	X		*	*	
Roundup®, others (12h/14d)	glyphosate	X	X				X	X	X	X	X	X	X
Sandea® (12h/30d)	halosulfuron	X	X	X		X	X		X	X	X	X	X
Select Max®, others (12h/20d)	clethodim			X			X	X			X	X	X
Sencor® (12h/7d)	metribuzin	X	X	X		X	X		X	X	X		
Spartan 4F® (12h/-)	sulfentrazone	X				X			X	X	X		
Treflan®, others (12h/-)	trifluralin	X	X		Yes	X		X	X		X	X	X

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted for at least one crop.
[3]X=may be used for that crop.
*=May be used for that crop if it is not on plastic mulch.

Insect Control for all Fruiting Vegetables

Aphids

Conserve natural enemies.

Limiting the use of some insecticides will conserve predators and parasites that help control aphid populations.

Recommended Products

RR **Actara**® at 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI.

Admire PRO® at the following rates:

Soil-applied to pepper: 7-14 fl. oz per acre. 21-day PHI.

Soil-applied to all others: 7-10.5 fl. oz. per acre. 7-day PHI.

Foliar applications: 1.3-2.2 fl. oz. per acre.

Do not exceed 14 fl. oz. per acre per season on pepper. Do not exceed 10.5 fl. oz. per acre per season for all others.

RR **Assail 30SG**® at 2-4 oz. per acre. Do not exceed 4 applications acre per season. 7-day PHI.

Belay 2.13SC® at 3-4 fl. oz. per acre. 7-day PHI for eggplant and tomato. 1-day PHI for pepper.

RR This is a reduced-risk pesticide. See page 34 for details.

Beleaf 50SC® at 2-2.8 fl. oz. per acre. *Aphids only.* 0-day PHI.

Closer 2SC® at 1.5-2 fl. oz. per acre. 1-day PHI.

Dimethoate 400® or **Dimethoate 4E**® at 0.5-1 pt. per acre. *Pepper and tomato only*. 7-day PHI for tomato. 2-day PHI for pepper.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. *Pepper and tomato only*. Do not exceed 2.66 qts. per acre per season. Do not exceed 2 applications per season on pepper. Do not exceed 4 applications per season on tomato. Do not use after July 31, 2015. 4-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 0-day PHI.

Lannate SP® at 0.25-1 lb. per acre. 1-day PHI for tomato. 3-day PHI for pepper. 5-day PHI for eggplant. *RUP*.

Malathion 5EC® at 1.5 pt per acre. 1-day PHI.

RR **Movento**® at 4-5 fl. oz. per acre. 1-day PHI.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

Orthene 97® at 0.5-1 lb. per acre. *Pepper only*. Do not exceed 2.12 lbs. per acre per season. 7-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. 30-day PHI.

Vydate L® at 2-4 pts. per acre. *Pepper and eggplant*: Do not exceed 24 pts. per acre per season. 7-day PHI for pepper. 1-day PHI for eggplant. *Tomato*: Do not exceed 32 pts. per acre per season. 3-day PHI. *RUP*.

Colorado Potato Beetles (tomato and eggplant only)

Practice crop rotation. Plant as far away as possible from last season's potato, tomato, or eggplant fields to reduce damage.

Regular (weekly) scouting will allow you to determine the need for insecticides and to improve application timing.

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3-2.2 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. Allow at least 7 days between applications. Do not exceed 48 fl. oz. per acre per season. Make no more than 2 successive applications. 7-day PHI.

Ambush 25W® at 12.8 fl. oz. per acre. 3-day PHI for eggplant and pepper. 0-day PHI for tomato.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. 1-day PHI for tomato. 7-day PHI for eggplant. *RUP*.

RR **Assail 30SG**® at 1.5-2.5 oz. per acre. Do not exceed 20 oz. per acre per season. 7-day PHI.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for eggplant. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16 oz. per acre. *Eggplant*: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. 7-day PHI. *Tomato*: Do not exceed 4 applications per season. 1-day PHI. *RUP*.

Confirm 2F® at 6-16 fl. oz. per acre. 7-day PHI.

Coragen® at 3.5-5 fl. oz. per acre. 1-day PHI.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. *Tomato only*. Do not exceed 1.33 qts. per acre per season. Do not use after July 31, 2015. 4-day PHI.

Entrust® at 1-2 oz. per acre. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Exirel® at 7-13.5 fl. oz. per acre. 1-day PHI.

Kryocide® at 8-16 lbs. per acre. Do not exceed 64 lbs. per acre per season. 14-day PHI.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. *RUP*.

RR **Platinum**® at 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. 30-day PHI.

Pounce 25WP® at 3.2-12.8 oz. per acre. *Tomato*: Do not exceed 4.8 lbs. per acre per season. 0-day PHI. *Eggplant*: Do not excced 8 lbs. per acre per season. 3-day PHI.

Prokil Cyolite 50D® at 15-30.5 lbs. per acre. Do not exceed 112 lbs. per acre per season. 14-day PHI.

RR **Radiant SC**® at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Rimon 0.83EC® at 9-12 fl. oz. per acre. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Vydate L® at 2-4 pts. per acre. Do not exceed 32 pts. per acre per season. 3-day PHI for tomato. 1-day PHI for eggplant.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. *RUP*.

Flea Beetles

Recommended Products

RR **Actara®** at 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI

Admire PRO® at the following rates:

Pepper: 7.0-14 fl. oz. per acre. Do not exceed 14 fl. oz. per acre per season.

Eggplant and tomato: 7.0-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season.

21-day PHI for soil applications. 7-day PHI for foliar applications.

Ambush 25W® at 6.4-12.8 fl. oz. per acre. 3-day PHI for eggplant and pepper. 0-day PHI for tomato.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. 1-day PHI for tomato. 7-day PHI for eggplant and pepper. *RUP*.

Baythroid® at 2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for eggplant and pepper. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB®** at 5.3-16 oz. per acre. *Eggplant*: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. 7-day PHI. *Tomato*: Do not exceed 4 applications per season. 1-day PHI. *RUP*.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. *Tomato only*. Do not exceed 1.33 qts. per acre per season. Do not use after July 31, 2015. 4-day PHI.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. *RUP*.

RR **Platinum®** at 5-11 fl. oz. per acre. 30-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. *Pepper and eggplant only*. Do not exceed 8 lbs. per acre per season. 3-day PHI. *RUP*.

Sevin XLR PLUS® at 0.5-1 qt. per acre. Do not exceed 8 qts. per crop. 3-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. *RUP*.

Mites, Spider Mites, and Russet Mites

Recommended Products

RR **Acramite 50WS®** at 0.75-1 lb. per acre. *Spider mites only*. Do not exceed 1 application per season. 3-day PHI.

Agri-mek 0.7SC® at 8-16 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 7-day PHI. *RUP*.

RR **Oberon 2SC®** at 7-8.5 fl. oz. per acre. *Spider mites only*. Do not exceed 25.5 fl. oz. per acre per season. 1-day PHI.

Portal 0.4EC® at 2 pts. per acre. Limit 2 applications per season. 1-day PHI.

Wettable sulfur (84-95%) at 10 lbs. per acre. Sulfur dusts also are effective. Thorough coverage is required. Do not apply when temperatures are above 95°F or during a heavy dew.

Zeal 72WP® at 2-3 oz. per acre. *Spider mites only. Pepper and eggplant only.* Limit 1 application per season. 7-day PHI.

Cutworms, Hornworms, Fruitworms, Pinworms and European Corn Borers

Recommended Products

Ambush 25W® at 6.4-12.8 fl. oz. per acre. 3-day PHI for eggplant and pepper. 0-day PHI for tomato.

Asana XL® at the following rates:

Cutworms, pinworms and fruitworms: 5.8-9.6 fl. oz. per acre.

Hornworms: 2.9-5.8 fl. oz. per acre.

Not for European corn borers. Do not apply more than 0.35 lb. a.i. per acre per season. 1-day PHI for tomato. 7-day PHI for eggplant and pepper. *RUP*.

RR **Avaunt 30WDG®** at 2.5-3.5 oz. per acre. *Not for cutworms*. Use higher rate for fruitworms. *Can control European corn borer in bell pepper only*. Do not exceed 14 oz. per acre per season. 3-day PHI.

BP Various ***Bacillus thuringiensis*** products (Agree®, Biobit®, Dipel®, Javelin®, Lepinox®, Xentari®). Follow label directions. *Not for cutworms or pinworms*. 0-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

Baythroid® at the following rates:

Cutworms and pinworms: 2.1-2.8 fl. oz. per acre.

Hornworms and fruitworms: 1.6-2.8 fl. oz. per acre.

Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for eggplant and pepper. *RUP*.

Brigade 2EC® at 2.1-5.2 fl. oz. per acre, or **Brigade WSB®** at 5.3-12.8 oz. per acre. *Eggplant*: Do not exceed 0.2 lb. a.i. per acre per season. 7-day PHI. *Tomato*: Do not exceed 4 applications per season. 1-day PHI. *RUP*.

RR **Coragen®** at 3.5-5.0 fl. oz. per acre. Coragen® can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days control. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Danitol 2.4EC® at 10.67 fl. oz. per acre. *Not for cutworms or European corn borers*. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI.

Diazinon 50W® at 4-8 lbs. per acre. Apply before planting. *Cutworms on tomato only*. Do not exceed 5 applications per season.

Entrust® at 1-2 fl. oz. per acre. *Not for cutworms*. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Exirel® at 7-13.5 fl. oz. per acre. 1-day PHI.

RR **Intrepid 2F®** at the following rates:

Early season on hornworms: 4-8 fl. oz. per acre.

Mid- to late season on hornworms: 8-16 fl. oz. per acre.

Fruitworms: 10-16 fl. oz. per acre.

Not for cutworms or pinworms. Do not exceed 64 fl. oz. per acre per season. 1-day PHI.

Lannate SP® at the following rates:

Cutworms: 0.5 lb. per acre.

Hornworms and fruitworms: 0.5-1.0 lb. per acre.

1-day PHI for tomato. 3-day PHI for pepper. 5-day PHI for eggplant. *RUP*.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 8 lbs. per acre per season. 3-day PHI for pepper and eggplant. 0-day PHI for tomato. *RUP*.

RR **Radiant SC®** at 5-10 fl. oz. per acre. *Not for cutworms*. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Sevin XLR PLUS® at 1-2 qts. pre acre. Do not exceed 8 qts. per acre per season. 3-day PHI.

Warrior II® at the following rates:

Cutworms and hornworms: 0.96-1.6 fl. oz. per acre.

Fruitworms and pinworms: 1.28-1.92 fl. oz. per acre.

Do not exceed 23 fl. oz. per acre per season. 5-day PHI. *RUP*.

Stink Bugs (including Marmorated Stink Bug)

Recommended Products

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for pepper and eggplant. *RUP*.

Belay 2.13SC® at 3-4 fl. oz. per acre. 7-day PHI for eggplant and tomato. 1-day PHI for pepper.

Brigade 2EC® at 2.1-5.2 fl. oz. per acre, or **Brigade WSB®** at 5.3-12.8 oz. per acre. *Eggplant*: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. 7-day PHI. *Tomato*: Do not exceed 4 applications per season. 1-day PHI. *RUP*.

Danitol 2.4EC® at 10.67 fl. oz. per acre. *Tomato only*. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. *Tomato only*. Do not exceed 1.33 qts. per acre per season. Do not use after July 31, 2015. 4-day PHI.

Mustang MAX® at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI.

Venom® at 1-4 oz. per acre. 1-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. *RUP*.

Whiteflies

Recommended Products

RR **Actara®** at 3.0-5.5 oz. per acre. Do not exceed 11.0 oz per acre per season. 0-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Admire PRO® at the following rates:

Soil-applied to pepper: 7.0-14 fl. oz. per acre. Do not exceed 14 fl. oz. per acre per season.

Soil-applied to eggplant and tomato: 7.0-10.5 fl. oz. per acre. Do not exceed 5 fl. oz. per acre per season.

Foliar applications: 1.3-22 fl. oz. per acre.

21-day PHI for soil applications. 0-day PHI for foliar applications.

Asana XL® at 5.8-9.6 fl. oz. per acre. *Not for eggplant*. Do not apply more than 67.2 fl. oz. per acre per season. 1-day PHI for tomato. 7-day PHI for pepper. *RUP*.

RR **Assail 30SG**® at 2.5-4 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Brigade 2EC® at 2.1-5.2 fl. oz. per acre, or **Brigade WSB**® at 5.3-12.8 oz. per acre. *Eggplant*: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. 7-day PHI. *Tomato*: Do not exceed 4 applications per season. 1-day PHI. *RUP*.

Closer 2SC® at 4.25-4.5 fl. oz. per acre. 1-day PHI.

Danitol 2.4EC® at 7-10.67 fl. oz. per acre. *Tomato only*. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. *Tomato only*. Do not exceed 1.33 qts. per acre per season. Do not use after July 31, 2015. 4-day PHI.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 0-day PHI.

RR **Knack**® at 8-10 fl. oz. per acre. Do not exceed 2 applications per acre per season. 14-day PHI.

RR **Movento**® at 4-5 fl. oz. per acre. 1-day PHI.

M-Pede® at 1-2% by volume. Must contact whiteflies to be effective. 0-day PHI.

Neemix® according to label directions. 0-day PHI.

RR **Oberon 2SC**® at 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 1-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. No more than 1 application per season. 30-day PHI.

Fruit Flies and Vinegar Flies (Drosophila spp.)

Starting 2 weeks before harvest, place bait fruits in fields in late afternoon, and examine next morning. If half of the baits show eggs, spray fields immediately at 4-6 day intervals with dust fruit and hampers as soon as filled with a dust containing 0.1% stabilized pyrethrins plus 1.0% piperonyl butoxide, and move hampers to processing plant as soon as possible.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Producing vegetables in high tunnels allows growers to extend the growing season and exploit new market windows.

Leafy Vegetables

Endive, Herbs, Lettuce, Parsley, and Spinach

Varieties		
Salad Greens	Endive	Full Heart Batavian, Green Curled Ruffoc
	Leaf Lettuce	Tiara, Glossy Green, Green Wave, New Red Fire, Sierra, Vulcan, Tango (oakleaf), Lolla Rossa
	Butterhead	Buttercrunch, Esmeralda, Ermosa (for trial)
	Head Lettuce	Ithaca, Maverick (for trial), Montello (for trial)
	Spinach	Bloomsdale Long Standing (spring), Early Hybrid No. 7 (fall), Early Hybrid No. 10 (fall), Old Dominion (fall), Virginia Savoy (fall), Tyee, Melody, Decatur, Unipak 151 (semi-savoy)

Spacing

These crops can have a common between-row spacing for convenience in cultivating.

Spinach: Rows 12 to 18 inches apart. Plants 4 to 6 per foot of row. Seed 12 to 20 pounds per acre.

Lettuce and Endive: Rows 12 to 15 inches apart. Plants 10 to 16 inches apart in row. Seed 1 to 2 pounds per acre.

Fertilizing

Lime: To maintain soil pH of 6.5 to 6.8. Spinach is particularly sensitive to soil acidity.

Preplant: N: 60 pounds per acre. P_2O_5: 0 to 150 pounds per acre. K_2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state.

Sidedress N: for soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, apply 30 pounds N per acre. For soils with less than 3 percent organic matter and the above rotation, apply 45 pounds N per acre. Following corn, rye, oats, wheat, or a vegetable crop, apply 60 pounds N per acre. Use a total of 90 to 120 pounds N per acre for culinary herbs. For herbs grown for seeds, such as coriander, fennel, and dill, use 60 to 90 pounds N acre.

Disease Control

Botrytis Gray Mold

In greenhouse production, avoid condensation on foliage by providing adequate ventilation within the enclosure and avoiding overcrowding plants.

Recommended Products

Botran 75W® or **Botran 5F**® at planting. Rate depends on crop and application method. *Lettuce and endive only*.

(RR) **Endura**® 8-11 oz. per acre. 14-day PHI. *Lettuce only*.

Fontelis® at 14-24 fl. oz. per acre. 3-day PHI.

Merivon® at 8-11 fl. oz. per acre. 1-day PHI.

Switch 62.5WG® at 11-14 oz. per acre. 0-day PHI.

Damping-Off

Conditions that favor rapid germination limit damping off severity. Avoid excessive irrigation and poorly drained soils. Good sanitation is critical to avoiding damping-off.

Recommended Products

Previcur Flex® See label for rates and greenhouse uses. *For damping-off of lettuce caused by Pythium and Phytophthora*.

Ridomil Gold SL® at 1-2 pts. per acre applied pre-plant, to control damping-off.

Downy Mildew, White Rust

Plant downy mildew-resistant varieties.

Recommended Products

Actigard® at the following rates:

Spinach: 0.5-0.75 oz. per acre.

Lettuce: 0.75-1 oz. per acre. *Downy mildew only*.

Not for herbs. 7-day PHI.

Agri-Fos 50WP® at 0.5 gal. per acre in 40 gals. water. *Not for herbs. Downy mildew only.* 0-day PHI.

Aliette® at 2-5 lbs. per acre. 3-day PHI.

Dithane F-45® at 1.2-1.6 qts. per acre. Supplemental label required. *Downy mildew on lettuce only*. 10-day PHI for head lettuce. 14-day PHI for leaf lettuce.

(RR) This is a reduced-risk pesticide. See page 34 for details.

Merivon® at 4-11 fl. oz. per acre. *Downy mildew suppression only.* 1-day PHI.

Phostrol® at 2.5-5 pts. per acre. *Downy mildew only*. 0-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.

Previcur Flex® at 2 pts. per acre. *Lettuce and downy mildew only*. 2-day PHI.

RR **Quadris**® at the following rates:

Downy mildew: 12.0-15.5 fl. oz. per acre.

White rust: 6.2-15.4 fl. oz. per acre.

0-day PHI.

Ranman® at 2.75 fl. oz. per acre. 0-day PHI.

RR **Revus 2.09SC**® at 8 fl. oz. per acre. *Downy mildew only*. 1-day PHI.

Ridomil Gold SL® at 0.25 pt. per acre. *Spinach only*. 7-day PHI.

Satori® at the following rates:

Downy mildew: 12.0-15.5 fl. oz. per acre.

White rust: 6.2-15.4 fl. oz. per acre.

0-day PHI.

Tanos 50WP® at 8-10 oz. per acre. *Not for herbs*. 1-day PHI.

Zampro® at 14 fl. oz. per acre. Downy mildew only. Do not use with herbs except for fennel. 0-day PHI.

Bottom Rot and Drop (lettuce)

Bottom rot is caused by *Rhizoctonia*. Lettuce drop is caused by *Sclerotinia*. Avoid poorly drained fields with a history of the disease.

Recommended Products

Botran 75W® or **Botran 5F**®. Rate varies by application method. *Lettuce drop only*.

RR **Endura 70WG**® at 8-11 oz. per acre. *Lettuce only*. Bottom rot is suppression. 14-day PHI.

Fontelis® at 16-24 fl. oz. per acre. *Lettuce drop only*. 3-day PHI.

Merivon® at 8-11 fl. oz. per acre. *Lettuce drop only.* 1-day PHI.

Fusarium Wilt (basil)

Basil varieties with Fusarium wilt resistance are available.

Powdery Mildew

Recommended Products

Fontelis® at 14-24 fl. oz. per acre. 3-day PHI.

Merivon® at 4-11 fl. oz. per acre. 1-day PHI.

RR **Quintec**® at 4-6 fl oz per acre. *Lettuce only*. Supplemental label needed. 1-day PHI.

Lettuce Mosaic Virus (LMV)

This virus can be carried in infested seed and is spread by aphids. Sow only mosaic-free indexed seed (sold as MTO). Control aphids and weeds near to production areas. Keep new lettuce planting as far as possible from old lettuce plantings. Disk under lettuce fields as soon as possible after final harvest.

Weed Control

Weed control in leafy vegetables often relies heavily on cultivation and hand weeding. These operations are most efficient when planting arrangement is designed with weed control in mind, and is designed to work with available weed control equipment. Specialized weeding equipment for leafy vegetables includes basket weeders, narrow-bladed hoes, and others. Using a stale seedbed is helpful to reduce weed pressure in the crop. For direct-seeded crops, a carefully timed weed-killing operation after the crop is seeded and just before emergence will buy a few weeks of time before cultivation or hand weeding is necessary. Just before the crop emerges, weeds could be killed with a flame weeder, or an approved nonselective herbicide. Using transplants is helpful for weed control because the size difference between weeds and crop early in the season make mechanical control easier. Plastic and paper mulches have been used with success for transplanted crops.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Application Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2-4 pts. per acre. *Endive and lettuce only*. *Not for spinach, parsley, radicchio, or herbs*. Include 1 qt. of COC or 4-8 fl. oz. of nonionic surfactant per 25 gallons of spray solution. Apply before or after seeding but before crop emerges. *RUP.*

RR This is a reduced-risk pesticide. See page 34 for details.

RR **Glyphosate** products at 0.75-3.75 lbs. acid equivalent (ae) per acre. *Basil, endive, Florence fennel, lettuce, parsley, radicchio, and spinach only*. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before seeding, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested applications volume and adjuvants. 14-day PHI.

Preemergence Broadleaves and Grasses

Recommended Products

Balan 60DF® at 2-2.5 lbs. per acre. *Lettuce only*. Apply and incorporate before seeding or transplanting.

Dual Magnum® at 0.33-1 pt. per acre. *Spinach in Indiana and Ohio only.* Apply after seeding before crop emerges. Incorporation is not recommened. Do not exceed 1 pt. per acre per crop or 1 application per crop. 50-day PHI.

Kerb 50WP® at the following rates:

Endive only: 2-3 lbs. per acre.

Lettuce only: up to 4 lbs. per acre. Use lower rate on coarse soils. Apply before or after seeding but before crop emerges.

May also be applied postemergence to endive and crisphead lettuce. Mechanical incorporation or rainfall required for effectiveness. Do not exceed 1 application per crop per year. 55-day PHI. *RUP*.

Lorox 50DF® at 1.5-3 lbs. per acre. *Parsley only and east of the Mississippi River only*. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Apply after seeding before crop emerges. On muck soils, may be applied at 1 lb. per acre to control small emerged weeds after parsley has 3 true leaves. Do not exceed 3 lbs. per acre per season. 30-day PHI.

Trifluralin products at 0.5-0.75 lb. a.i. per acre. Apply 4EC formulations at 1-1.5 pts. per acre. *Endive and radicchio only*. *Not for Florence fennel, herbs, lettuce, spinach, or parsley*. Use lowest rate on coarse soils. Apply and incorporate before planting. Not effective on soils with high organic matter.

Preemergence Grasses

Recommended Products

Prefar 4E® at 5-6 qts. per acre. *Lettuce, endive, Florence fennel, and radicchio only*. *Not for herbs or spinach*. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting, or apply after seeding before crop emerges and irrigate within 24 hours.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Spin-Aid 1.3E® at 3-6 pts. per acre in 11-22 gals. of water. *For spinach grown for processing or seed only*. Apply to spinach with 4 true leaves to avoid injury. Do not apply if spinach is stressed. Does not control pigweed. 40-day PHI.

Stinger 3L® at 4-8 fl. oz. per acre. *Spinach only*. Controls mainly composites and nightshade. Do not exceed 8 oz. per acre per year. 21-day PHI.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Maximum 64 fl. oz. Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Maximum 32 fl. oz. Select 2EC® per acre per season.

Herbs may vary in sensitivity. Test on a small area before applying to entire crop. Apply to actively growing grass. Wait at least 14 days between applications. 14-day PHI for lettuce and spinach. 30-day PHI for Florence fennel.

Poast® 1.5E at the following rates:

Endive, dill, Florence fennel, lettuce, parsley, radicchio, and spinach: 1-1.5 pts. per acre.

Dill: up to 2.5 pts. per acre. Do not exceed 5 pts. per acre per season.

Not for herbs other than dill. Use with 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 3 pts. per acre per season. 14-day PHI for dill. 15-day PHI for leaf lettuce, spinach, endive, and parsley. 30-day PHI for fennel, head lettuce, and radicchio.

Herbicides for Leafy Vegetables[1]

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop					Incorporated	Timing Relative to Weeds		Weed Groups Controlled			Crops[2]					
		Before seeding	After seeding before emergence	Before transplanting	Post emergence -between rows only	Postemergence		Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Endive	Florence Fennel	Lettuce	Parsley	Radicchio	Spinach
Gramoxone Inteon 2L® (12h to 24h)	paraquat	X	X						X	X	X	X	X		X			
Roundup®, others (12h/14d)	glyphosate	X			X				X	X	X	X	X	X	X	X	X	X
Aim EC® (12h)	carfentrazone				X				X		X	X	X	X	X	X	X	X
Balan 60DF® (12h/-)	benefin	X		X			Yes	X		X	X				X			
Dual Magnum® (24h/50d to 60d)	s-metolachlor		X					X		X	X							X
Kerb 50WP® (24h/55d)	pronamide	X	X			X		X		X	X		X		X			
Lorox 50DF® (24h/30d)	linuron		X			X		X		X						X		
Treflan®, others (12h/-)	trifluralin	X					Yes	X		X	X		X				X	
Spin-Aid® (12h/40d)	phenmediphan					X			X		X	X						*
Stinger® (12h/21d)	clopyralid					X			X		X	X						X
Prefar 4E® (12h/-)	bensulide	X	X	X			Yes	X		X			X	X	X		X	
Select Max®, others (12h/14d to 32 d)	clethodim					X			X	X			X	X	X	X	X	X
Poast® (12h/14d to 30d)	sethoxydim					X			X	X			X	X	X	X	X	X

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=may be used for that crop. *=Processing crops only.

Insect Control

Aphids, Leafminers, Mites

Treat when insects reach the economic thresholds described below.

Seedlings

Aphids

2 per plant

Leafminers

50% of plants infested

Established Plants

Aphids

7 per plant

Near Harvest

Leafminers

5% of leaves infested

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. *Aphids only*. Do not exceed 11 oz. per acre per season. 7-day PHI.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

Aphids only. Do not exceed 0.38 lb. a.i. per acre per season.

Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. *Leafminers and mites only*. Do not exceed 2 applications or 48 fl. oz. per acre per season. Use NIS. 7-day PHI. *RUP*.

Ambush 25W® at 6.4-12.8 oz. per acre. *Leafminers only*. *Spinach*: Do not exceed 1 lb. a.i. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

RR **Assail 30SG**® at 2-4 oz. per acre. *Aphids only*. Do not exceed 20 oz. per acre per season. 7-day PHI.

Belay 2.13SC® at 3.4 fl. oz per acre. 7-day PHI.

Beleaf 50SG® at 1.2-2.8 oz per acre. *Aphids only*. 0-day PHI for lettuce, spinach.

Closer 2SC® at 1.5-2 fl. oz. per acre. 3-day PHI.

Dimethoate 4E® or **Dimethoate 400**® at 0.5 pt. per acre. *Not for parsley, spinach, celery or head lettuce*. 14-day PHI for endive, swiss chard, and leaf lettuce.

Endosulfan® at 1-1.33 qts. per acre. *Lettuce and spinach only*. Do not exceed 2 applications per season. Do not use after July 31, 2015. 14-day PHI.

Entrust® at 2-3 oz. per acre. *Leafminers only*. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. *Aphids only*. Do not exceed 5.5 oz. per acre per season. 7-day PHI.

Malathion 5EC® at 2 pts. per acre. 14-day PHI for leaf and head lettuce. 7-day PHI for endive and spinach.

RR **Movento**® at 4-5 fl. oz. per acre. *Aphids only*. 3-day PHI.

M-Pede® at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

BP **Neemix**® according to label directions. *Aphids and leafminers only*. 0-day PHI.

RR **Oberon 2SC**® at 7-8.5 fl. oz. per acre. *Mites only*. Do not exceed 25.5 fl. oz. per acre per season. 7-day PHI.

Orthene 97® at 0.5-1 lb. per acre. *Aphids on head lettuce only*. Do not exceed 2 1/8 lbs. a.i. per acre per season. 21-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. *Aphids only*. 30-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. *Leafminers only*. *Spinach*: Do not exceed 4 lbs. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

RR **Radiant SC**® at 6-10 fl. oz. per acre. *Leafminers only*. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Torac® at 17-21 fl. oz. per acre. *Aphids only*. Do not exceed 2 applications per season. 1-day PHI.

Trigard® at 2.66 oz. per acre. *Leafminers only*. Do not exceed 6 applications per acre per season. 7-day PHI.

Carrot Weevil

For parsley, scout plants at the 4-leaf stage, looking for ovipunctures (egg-laying scars) on the stems. Treat if ovipunctures are found on at least 1% of plants.

Recommended Products

Baythroid XL 1EC® at 3.2 fl. oz. per acre. 0-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Caterpillars, Loopers

Treat when 5% of plants are infested.

Recommended Products

Ambush 25W® at 3.2-12.8 oz. per acre. *Spinach*: Do not exceed 4 lbs. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

RR **Avaunt 30WDG**® at the following rates:

Spinach: 3.5 oz. per acre. Do not exceed 14 oz. per acre per season.

Other labeled crops: 2.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season.

3-day PHI.

BP Various ***Bacillus thuringiensis*** products (Agree®, Biobit®, Dipel®, Javelin®, Lepinox®, Xentari®) are available in various formulations. Follow label instructions for rates and use. 0-day PHI.

Baythroid® at the following rates:

Cabbageworm and loopers: 1.6-2.4 fl. oz. per acre.

Armyworms, corn earworm, and European corn borer: 2.4-3.2 fl. oz. per acre.

Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16 oz. per acre. *Head lettuce and spinach only*. *Head lettuce*: Do not exceed 1 qt. of 2EC per acre per season; do not exceed 80 oz. of WSB per acre per season. 7-day PHI. *Spinach*: Do not exceed 25.6 fl. oz. of 2EC per acre per season; do not exceed 64 oz. of WSB per acre per season. 40-day PHI. *RUP*.

Confirm 2F® at 6-8 fl. oz. per acre. 7-day PHI.

Coragen® at 3.5-5 fl. oz. per acre. 1-day PHI.

Entrust® at 1-2.0 oz. per acre. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Exirel® at the following rates:

Loopers: 10-17.5 fl. oz. per acre.

All others: 7-13.5 fl. oz. per acre.

1-day PHI.

RR **Intrepid 2F**® at the following rates:

Early season applications: 4-8 fl. oz. per acre.

Mid- to late-season applications: 8-10 fl. oz. per acre.

Do not exceed 64 fl. oz. per acre per season. 1-day PHI.

Lannate SP® at 0.5-1 lb. per acre. Maximum application amounts and PHIs vary among vegetables. Read and follow label directions. *RUP*.

Larvin 3.2® at 16-30 fl. oz. per acre. Do not exceed 60 fl. oz. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. *RUP*.

Orthene 97® at 1 lb. per acre. *Head lettuce only*. Do not exceed 2.2 lbs. per acre per season. 21-day PHI.

Pounce 25WP® at 3.2-12.8 oz. per acre. *Spinach*: Do not exceed 4 lbs. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

Flea Beetles, Leafhoppers

Flea Beetle Threshold

Seedlings: >50% plants infested and defoliation > 30%

Recommended Products

RR **Actara**® at 1.5-3.0 oz. per acre. Do not exceed 11 oz. per acre per season. 7-day PHI.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

Leafhoppers only. Do not exceed 0.38 lb. a.i. per acre per season.

Ambush 25W® at 6.4-12.8 oz. per acre. *Leafhoppers only*. *Spinach*: Do not exceed 4 lbs. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

Ammo 2.5EC® at 2.5-5.0 fl. oz. per acre. *Head lettuce only*. Do not exceed 30 fl. oz. per acre per season. 5-day PHI. *RUP*.

Baythroid® at the following rates:

Flea beetles: 2.4-3.2 fl. oz. per acre.

Potato leafhoppers: 0.8-1.6 fl. oz. per acre.

Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI. *RUP*.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16 oz. per acre. *Head lettuce and spinach only*. 7-day PHI for head lettuce. 40-day PHI for spinach. *RUP*.

Dimethoate 4E® or **Dimethoate 400**® at 0.5 pt. per acre. *Leafhoppers only*. *Not for parsley, spinach, celery, or head lettuce*. 14-day PHI for endive, swiss chard, and leaf lettuce.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 5-day PHI. *RUP*.

BP **Neemix**® according to label directions. 0-day PHI.

RR **Platinum**® at 5-11 fl. oz. per acre. 30-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. *Leafhoppers only*. *Spinach*: Do not exceed 4 lbs. per acre per season. *All others*: Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

Sevin XLR PLUS® at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per season. 14-day PHI.

Torac® at the following rates:

Leafhoppers: 14-21 fl. oz. per acre.

All others: 17-21 fl. oz. per acre.

Do not exceed 2 applications per season. 1-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. *Lettuce only*. Do not exceed 19.2 fl. oz. per acre per season. 1-day PHI. *RUP*.

These parsley transplants will have an advantage over plants that are direct seeded.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

Herbs

Most herbs will grow well under the same sunlight, fertility, soil and growing conditions, and cultural techniques similar to many vegetable crops. Pay special attention to drainage and moisture requirements of certain herbs, since many are very sensitive to soil moisture conditions.

Sage, rosemary, and thyme require well-drained, slightly moist soil, while parsley, chervil, and mint grow best on soils that retain moisture. Using plastic mulches, trickle irrigation, and raised beds may provide the necessary moisture and drainage requirements for the herb crop.

Spacing

Raised beds are recommended for culinary herbs. These crops usually have common between-row spacing for convenience in cultivating. See individual herbs for details.

Lime and Fertilizer

Muck Soils: Maintain soil pH between 5.5-6.0. Consider liming on muck soils when the pH falls below 5.5. Apply all fertilizer in a broadcast application and disk in prior to planting.

Mineral Soils: Maintain a soil pH of 6.0-7.0. For average-fertility soils, apply 120 to 150 pounds of N per acre, 120 to 180 pounds of P_2O_5 per acre, and 120 to 180 pounds of K_2O per acre. Apply half before planting and the remainder as bands at planting, 2 inches to the side and 2 inches below the seed. Sidedress with 30 pounds of N per acre three to four weeks after thinning or transplanting.

Preplant: N: 60 pounds per acre. P_2O_5: 0 to 150 pounds per acre. K_2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state.

Sidedress N: For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, apply 30 pounds N per acre. For soils with less than 3 percent organic matter and the above rotation, apply 45 pounds N per acre. Following corn, rye, oats, wheat, or a vegetable crop, apply 60 pounds N per acre. Use a total of 90 to 120 pounds N per acre for culinary herbs. For herbs grown for seeds, such as coriander, fennel, and dill, use 60 to 90 pounds N acre.

Pest Control

Plastic or organic mulch is recommended for weed control. Most herbs are weak competitors to weeds, and herbicides are not available. Good sanitation and attention to seed source will help to lessen diseases. For more information on pest control in herbs, see the leafy greens chapter.

Marketing

Fresh herbs certainly make excellent cash crops. However, growers should be very cautious before beginning herb production. Establish markets and buyers need before purchasing any seed. Some of the most popular culinary herbs include basil, chives, dill, French tarragon, mints, oregano, parsley, rosemary, and thyme. However, growers should do their own marketing study to determine which herbs are suited for their areas.

Possible outlets of culinary herbs include health food stores, grocery stores, upscale restaurants, farmers markets, and food manufacturing companies. Growers are also strongly encouraged to have greenhouses for year-round production.

Detailed descriptions of some popular herbs appear below.

Basil

Basil, French basil, or sweet basil (*Ocimum basilicum*) is a popular, tender, annual herb. It is native to India and Asia.

Basil is commercially grown for its green, aromatic leaves, which are used fresh or dried as a flavoring. Fresh basil leaves are used in tomato sauces and pesto sauces. Basil is also good with veal, lamb, fish, poultry, white beans, pasta, rice, tomatoes, cheese, and eggs. It is used in vinegar and tea.

Basil can be direct-seeded or transplanted to the field in late spring after all danger of frost is over. Basil seeds normally germinate in 8 to 14 days. Basil requires full sun and prefers moist, well-drained soil with a pH of 6.0. Typical spacing for basil is 12 inches between plants, 24 to 36 inches between rows. Suggested fertilizer should have an N-P-K ratio of 1-1-1 at a rate of 120-120-120 pounds per acre by a broadcast or plowdown. Sidedressing N at a rate of 15 to 30 pounds of actual N is recommended shortly after first harvest.

Trickle or overhead irrigation is necessary. Basil grown for dried leaves or essential oil is cut just prior to the appearance of flowers. The foliage should be cut at least four to six leaves above the ground to allow for regrowth and a subsequent crop. Information about insects and disease of basil is limited. Japanese beetle, powdery mildew, and downy mildew have been reported to attack basil. For weed control, a higher basil plant population coupled with mechanical cultivation is highly recommended. Refer to *Sweet Basil: A Production Guide*, Purdue Extension publication HO-189-W, available from the Education Store, www.the-education-store.com.

Chives

Chives, *Allium schoenoprasum,* is a perennial that is native to Asia. It was first used by the Chinese and then the ancient Greeks. Fresh leaves are excellent for making herbal vinegars and butter. It is also used in salad, soup, and cheese. Chives are also used to add a mild onion flavor to fish, salads, steamed vegetables, soups, and omelettes.

Chive seeds require darkness, constant moisture, and a temperature of 60°F to 70°F for best results. Sow them ½ inch deep in pots or flats. Germination will occur in 2 to 3 weeks. Transplant seedlings to the field when they are 4 weeks old. Chives reach a height of 18 inches, a width of 1 to 2 inches the first year from seed, and 10 to 14 inches in subsequent years. Chives require full sun and well-drained soil with a pH of 6.0. No serious pests or diseases were reported although chives can get downy mildew and rust. To harvest chives, cut chive leaves 2 inches above the ground.

Cilantro

Cilantro, *Coriandrum sativum,* is an herb with a unique scent and flavor. Native to Egypt, cilantro is one of the most ancient herbs still cultivated. It is also known as Mexican parsley, Chinese parsley, or coriander. The dried seedpod is known as coriander and is usually used as a spice in baking and desserts. Cilantro leaves are a well-known salsa ingredient.

This annual plant does best in cool weather and should be planted in the early spring or in the fall. Optimum growing temperatures are between 50°F to 85°F. Plant seeds 1/2 inch deep and 2 to 3 inches apart. Germination may take 10-14 days. Cilantro grows 2 to 3 feet tall and thrives in moderately rich, light, well-drained soil in full to partial sun. Cilantro is highly salt sensitive and soil electrical conductivity values exceeding 1 dS/m could reduce yields. Plants have shallow root systems, so frequent irrigation is needed. Cabbage looper and green peach aphid sometimes cause economic damage by curling and twisting leaves, and stunting the plant. Bacterial leaf spot, which is seedborne, and Fusarium wilt are common diseases in cilantro production. Effective management strategies involve using clean seed material and avoiding fields that have a history of Fusarium. To harvest, cut cilantro either just below the soil or 1.5 to 2 inches above the crown, bunched, and tied together with a rubber band. Popular cultivars include Long Standing, Santos, and Calypso.

Dill

Dill, *Anthum graveolens,* is native to the Mediterranean area and southern Russia. It is a hardy annual, and sometimes is grown as a biennial. Dill is commonly used as a seasoning for soups, fish, and pickles. Its aromatic leaves, seeds, flowers, and stems can also be used to flavor cabbage, vinegar, butter, apple pie, cakes, and bread.

Direct-seed in spring about 10 inches apart. Since dill has long taproots, it should not be transplanted. Fresh leaves should be harvested before flowering begins. Harvest seeds as soon as seed heads are brown and dry. Dill does not have any serious pest or disease problems. However, phoma blight, rusty root, and stem rot have been reported.

Fennel

Fennel (*Foeniculum vulgare*) is a cool-season aromatic herb that originated in the Mediterranean region. It is a perennial but usually grown as an annual that grows to about 3 to 4 feet tall. Leaves are used as potherbs and for seasoning and garnishing purposes along with the bulb, which could be used as a fresh salad.

Planting can be done using seeds or transplants. Plant in full sun in rich and well-drained soil. Plant seeds at 1/4 to 1/2 inches deep in rows that are 2-3 feet apart. In-row spacing should be 10-12 inches. Transplant to the field early in the spring. Planting to harvesting for direct-seeded fennel could range from 90 to 150 days; and 110-125 days for transplanted fennel. Harvest by cutting just above the bulb near the leaf bases. Bulbs are further trimmed by cutting away most of the top growth. Leaf blight and stem rot are two major diseases affecting fennel.

French Tarragon

French tarragon, *Artemisia dracunculus,* originates from southern Europe. Do not confuse it with Russian tarragon, *Artemisia dracunculoides,* which is much coarser, and has paler leaves, and a bitter taste. French tarragon is used to flavor vinegar, herbal butter, shellfish, pork, beef, poultry, many vegetables, and rice. Fresh leaves can also be used in salads, tartar sauce, and French dressing. French tarragon is a woody perennial that will grow 2 feet tall.

It produces few seeds, and must be propagated by stem cuttings or division. Plant in full sun in rich, well-drained soil with a pH of 6.9. Divide the plants every three to four years. Two harvests can generally be made each year, the first six to eight weeks after setting out. Harvest until leaves turn yellow in the fall. French tarragon is prone to root rot in heavy and wet soils.

Mints

Mints, *Mentha* spp., are a group of herbs that are mostly native to Europe and Asia. Some are indigenous to South America, America, and Australia. It is naturalized throughout North America from southern Canada and Mexico. With the possible exception of Corsian mint, mints are such rampant growers that they will quickly overwhelm other plants. Mints are commercially important as sources of flavor and menthol. Japanese mint (*M. Arvensis* var. Piperescens), peppermint (*M. Xpipita*), and spearmint (*M. Spicata*) are the mint species mostly cultivated.

Mints can be propagated by cuttings or seeds, except peppermint, since it is a sterile F1 hybrid of *M. Aquatica* and *M. Spicata.* Peppermint does not produce seeds and can only be propagated by cuttings. Mints can be planted in full sun or partial shade, and require rich, well-drained soil with a pH of 6.5. Mint can be harvested almost as soon as it comes up in the spring. Young, tender leaves and stems are the best. Mint is susceptible to verticillium wilt, mint rust, and mint anthracnose. The pests that could bother mint include: spider mites, loopers, mint flea beetles, mint root borers, cutworms, root weevils, and aphids. For details, see Mint, page 159.

Oregano

Oregano, *Origanum vulgare* subsp. Hirtum also referred to as *O. Heracleoticum* and *O. Hirtum,* is native to the Mediterranean region. It is naturalized in the eastern United States. It is added to tomato sauce for a hot and peppery taste. It adds dimension to yeast breads, marinated vegetables, roasted meats, and fish.

Oregano is a perennial, and can be propagated by seeds. Direct-seed in the field and do not cover seeds since oregano seeds need sunlight to germinate. However, flavor can greatly vary among seed propagated plants. It is better to propagate by root divisions or cuttings from plants that are known to have strong flavor. Oregano reaches a height of 12 to 24 inches, and a width of 10 to 20 inches. It requires a site with full sun, and well-drained soil that has a pH of 6.8. Some of the pest and disease problems for oregano include aphids, leafminers, spider mites, and root rot. Oregano sprigs can be cut off when the plant is at least 6 inches high. In June, vigorously grown plants can be cut back to the lowest set of leaves. Plants will generally leaf out after two weeks and can be cut back again in August.

Parsley

Parsley is grown exclusively for its green leaves, or tops. The curled-leaf and Italian flat-leaf types are the most popular.

Field-seeding begins in early April and ends in May. Parsley is cut 1.5-2 inches from ground level to allow regrowth. About three or four cuttings are made, depending on the length of the growing season. Maintain soil pH at 5.5-6.0. Broadcast and disk in all fertilizer prior to planting. Apply 100 to 120 pounds of N per acre, 100 to 120 pounds of P_2O_5 per acre, and 100 to 120 pounds of K_2O per acre. After each cutting, broadcast 30 pounds of N per acre and cultivate. Row spacing should be 12 to 16 inches. Direct-seeding rate will depend on direct seeding equipment and could require 14 to 16 pounds per acre (70% germination). A 2-inch scattered shoe is used on most all planters. Row spacing depends on seeding equipment but is usually around 15 inches apart and in row plant spacing should be 4 to 8 inches. Seeding rate depends on seeding equipment and seed quality and could be up to 30 pounds per acre. Germination is enhanced by presoaking seeds in water for 24 hours, and then allowing them to partially dry.

Popular curled-leaf parsley cultivars include Moss Curled, Dark Moss Curled, Banquet, Decorator, Deep Green, Forest Green, Improved Market Gardener, Sherwood, and Perfection. Plain-leaf type cultivars include Plain and Plain Italian Dark Green. Hamburg type, which is grown for its enlarged edible root consists of the Hamburg cultivar.

Rosemary

Rosemary, *Rosmarinus officinalis,* is a tender perennial hardy to zones 8 to 10. It is native to the Mediterranean, Portugal, and northeastern Spain. It is pungent, somewhat piny, mint-like yet sweeter, with a slight ginger finale. Its flavor harmonizes with poultry, fish, lamb, beef, veal, pork, and game. Rosemary also enhances vegetables, cheese, and eggs.

Rosemary can be started from seeds, but germination rates are very low. Use fresh seeds, preferably less than two weeks old. Packaged seeds are difficult to germinate. Start plants from cuttings or by layering from existing plants. Rosemary grows slowly from seed, and eventually reaches a height of 72 inches and a width of 36 to 72 inches. Plant rosemary in a sunny location with well-drained and slightly acidic soil. Pest and disease problems include aphids, spider mites, scale, mealybugs, root rot, and Botrytis gray mold. Harvesting can be done throughout the year. Cut about 4-inch pieces from the tips of the branches, being careful not to remove more than 20 percent of the growth at one time.

Thyme

Thyme, *Thymus vulgaris,* is native to the western Mediterranean region. It is a small, many-branched, and perennial shrub. Thyme tastes delicately green with a faint clover aftertaste. It ranks as one of the finest herbs of French cuisine. Thyme leaves and sprigs are used in clam chowder, meats, herbal butter, and vinegar. Use it with vegetables, cheese, eggs, and rice.

Start seeds indoors and transplant seedlings into the field once the danger of frost is over. Thyme reaches a height of 12 inches and a width of 10 to 12 inches. Thyme can be propagated from cuttings, by layering, and division. The pest and disease problems include spider mites and root rot. Harvest the entire plant by cutting them back to 2 inches above ground in midsummer. One more harvest can be expected before the season ends.

Basil is a potentially high-value crop that may be grown successfully in a hydroponic setting.

Legumes — Snap Bean, Dry Bean, Lima Bean

Snap Bean Varieties	Use	Pod Color	Seed Color	Comments
Bush Snap Bean Varieties-Green Pod				
Benchmark	market	medium-dark green	white	excellent quality
Bronco	market	dark green	white	excellent quality, mechanical harvest
Daytona	market	medium green	white	
Envy	processing			
Evergreen	processing			
Flo	processing			
Hialeah	market	green	white	excellent quality
Hystyle	market, processing	dark green	white	mechanical harvest
Labrador	market, processing	dark green	white	
Opus	market	medium-light green	white	rust tolerant
Rushmore	market	medium green	brown	early
Strike	market	medium-light green	white	mechanical harvest
Tema	market	medium-dark green	brown	
Venture	market, processing	dark green	white	early
Yellow Pod				
Eureka	market	yellow	white	
Gold Mine	market	yellow	white	susceptible to brown spot
Gold Rush	market, processing	yellow	white	susceptible to brown spot
Kinghorn Wax	market	yellow	white	excellent quality
Klondyke	market	yellow	white	mechanical harvest
Nugget	market, processing	yellow	white	

Lima Bean Varieties	Use	Seed Color	Comments
Bridgeton	processing	greenish	Bush, late, medium size
Fordhook 242	market & home	white	Bush, midseason, medium size, variable yield
Henderson Bush	market & home	white	Bush, very early, small seed, high yield
King of the Garden	home garden	greenish-white	Pole, midseason to late, large seed

Legumes — Pea and Cowpea

"Pea" has been commonly used to describe two distinctly different legume crops. English and Snow peas, both *Pisum sativum*, are cool-season crops grown for their immature edible seeds or pods. Snap peas are a type of English pea with tender, edible pods. Southern peas, or cowpeas, are *Vigna unguiculata* and include black-eyed peas, cream peas and crowder peas. These heat-loving crops are more commonly grown in southern states, although they can be grown in the north. They are grown for their immature shelled seeds and are well-accepted in markets where customers are familiar with them.

Pea Varieties	Season	Comments
English Shell Peas		
Spring	early	
Knight	early	Short vines
Bolero	mid	
Green Arrow	mid-late	Long holding in field
Lincoln	mid-late	Very sweet, home garden variety
Snap peas (edible-podded)		
Sugar Bon	early	Short vines
Sugar Ann	early	Short vines
Cascadia	main	
Supersnappy	main	Large pods
Snow peas (edible-podded)		
Oregon Giant	mid-late	Large pods
Snowflake	late	Dark green
Super Sugar Pod	late	Long vines
Southern Peas or Cowpeas		
Brown Crowder		
Mississippi Silver (crowder)		
Purple Crowder		
Texas Cream Cowpea		
Zipper Cream Cowpea		

Spacing

Beans: Rows 18 to 36 inches apart, 5 to 7 seeds per foot of row. Larger inter-row spacing helps limit white mold development. Seed 70 to 100 pounds per acre.

Peas and Cowpeas: Rows 32 to 36 inches apart, 6 to 8 seeds per foot of row. Seed 100 to 150 pounds per acre.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.8.

Preplant: N: for soils with more than 3 percent organic matter and following soybeans, alfalfa or a grass-legume hay crop no N is needed. For soils with less than 3 percent organic matter and the above rotation apply 20 pounds N per acre for peas, and 30 pounds N per acre for beans. Following corn, rye, oats, wheat, or a vegetable crop apply 40 pounds N per acre for peas, and 40 to 60 pounds N per acre for beans. P_2O_5: 0 to 100 pounds per acre. K_2O: 0 to 100 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Micronutrients: beans are prone to zinc deficiency. If the soil test shows zinc below 0.7 ppm, then prior to planting broadcast and incorporate 5 pounds of zinc per acre, or include 1 pound zinc per acre in the fertilizer band at planting.

At Planting: Apply 12 pounds N and 48 pounds P_2O_5 per acre in bands at least 2 inches below and 2 inches to the side of the row. Potassium (K) is not recommended in the band because peas and beans are sensitive to injury from fertilizer salts.

Sidedress N: None needed.

Disease Control

Rust, Anthracnose (dry beans and peas)

Follow 2-3 year rotation schedules. Rust resistant varieties are available. Use seed free of the pathogen.

Recommended Products

Aproach® at 6-12 fl. oz. per acre. 14-day PHI.

RR **Bravo**®, **Echo**®, and **Equus**® are labeled for use at various rates. 14-day PHI.

Headline® at 6-9 oz. per acre. 21-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 21-day PHI.

Proline 480SC® at 5.7 fl. oz. per acre. *Rust only.* 7-day PHI.

RR **Quadris**® at the following rates:

Anthracnose: 6.2-15.4 fl. oz. per acre.

Rust: 6.2 fl. oz. per acre.

0-day PHI.

Quadris Opti® at 1.6-2.4 pts. per acre. 14-day PHI.

Quilt Xcel® at 10.5-14 fl. oz. per acre. 14-day PHI.

Topsin 70W®, or **Topsin 4.5L**®. See labels for rates. *Anthracnose only*. 28-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Rust, Anthracnose (snap beans and other succulent beans — check labels)

Follow 2-3 year rotation schedules. Rust resistant varieties are available. Use seed free of the pathogen.

Recommended Products

RR **Bravo**®, **Echo**®, and **Equus**®are labeled for use at various rates. 7-day PHI.

RR **Fontelis**® at 14-30 fl. oz. per acre. 0-day PHI.

RR **Headline**® at 6-9 oz. per acre. 7-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 7-day PHI.

RR **Quadris**® at the following rates:

Anthracnose: 6.2-15.4 fl. oz. per acre.

Rust: 6.2 fl. oz. per acre.

0-day PHI.

Quilt Xcel® at 10.5-14 fl. oz. per acre. 7-day PHI.

Rally 40WSP® at 4-5 oz. per acre. *Rust only*. 0-day PHI.

Topsin 70W®, or **Topsin 4.5L**®. See labels for rates. *Anthracnose only*. 28-day PHI.

Bacterial Blights

Plant western-grown, certified disease-free seed. Practice a 2-year crop rotation and plow under bean stubble in the fall. Apply a fixed copper product such as Kocide®, Champ®, or Cuprofix® at 5-7 day intervals to reduce spread (0-day PHI) if weather conditions favor disease spread.

Fusarium Wilt

Use resistant cultivars. Rotate away from legumes for several years to avoid build up of the Fusarium fungus.

Seed Rot and Damping Off

Use pathogen-free seed. Purchase seed commercially treated with a product such as Apron Maxx®, Captan®, or Thiram®. If Pythium and Rhizoctonia are a significant problem, apply Ridomil Gold PC GR® at 0.75 lb. per 1,000 feet of row at planting.

White Mold and Gray Mold

Avoid fields with a history of white mold or with poor drainage.

Recommended Products

Aproach® at 8-12 fl. oz. per acre. *White mold only.* 14-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. *Gray mold on snap bean only*. 7-day PHI.

BP **Contans WG**® at 1-4 lbs. per acre for white mold on snap beans. Contans® is applied with conventional spray equipment directly to the soil surface at planting.

RR **Endura 70WG**® at 8-11 oz. per acre. 7-day PHI for snap bean. 21-day PHI for dry beans.

RR **Fontelis**® at 14-30 fl oz per acre for gray mold, or at 16-30 fl. oz. per acre for white mold. 0-day PHI.

Rovral 75WG® at 1.5-2 pts. per acre. 0-day PHI.

Proline 480 SC® at 5.7 fl. oz. per acre. *White mold on dry beans only*. 7-day PHI.

Switch 62.5WG® at 11-14 oz. per acre. 7-day PHI.

Topsin 70W®, or **Topsin 4.5L**®. See labels for rates. 14-day PHI for snap beans. 28-day PHI for dry and lima beans.

Soybean Cyst Nematode (SCN)

Rotate at least 2-3 years with corn, small grains, alfalfa, or other non-host crops. Do not include soybeans in the rotation.

Bean Yellow Mosaic Virus (BYMV)

No adequate control measure is known. Eliminating overwintering host plants, such as wild sweet clover may reduce infection. Some tolerant varieties are available.

Weed Control

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Burndown or Directed/Shielded Application Broadleaves and Grasses

Recommended Products

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before seeding or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Gramoxone Inteon 2L® at 2-4 pts. per acre. *Lima bean, snap bean, and pea only*. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before seeding or after seeding but before crop emergence. *RUP*.

Spartan Advance®. See details below for Preemergence Broadleaves.

Burndown or Directed/Shielded Application Broadleaves

Aim EC® at 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours after seeding, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

Optill®. See detail below for Preemergence Broadleaves.

Sharpen® at 1-2 oz. burndown before the crop emerges. *Chickpeas and dry peas only*. Surface apply early pre-plant through pre-emergence. Add MSO at 1 pt. per acre when used as a pre-plant burndown. Do not apply group 14, E herbicides within 30 days of planting. Do not apply when legumes reach cracking stage.

Spartan Charge®. See details below for Preemergence Broadleaves.

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at the following rates:

Peas and cowpeas: 1.3 pts. per acre.

Succulent lima beans and snap beans: 0.4-0.67 pt. per acre.

Broadcast before planting, or after planting before crop emerges. Not effective on muck soil. 45-day PHI for succulent and snap beans.

Dual Magnum®, or **Dual II Magnum**® at 1-2 pts. per acre. Use lower rates on coarse soils. *Peas*: apply prior to planting. Do not incorporate in English peas. *Beans*: apply and incorporate before planting, or apply after seeding but before crop emerges. Can be tank-mixed preplant incorporated with Eptam® or trifluralin. Do not use on muck soils.

Eptam 7E® at 3.5 pts. per acre, or **Eptam 20G**® at 15 lbs. per acre. *Dry beans and snap beans only*. Apply before planting and incorporate immediately, or apply as a directed spray at last cultivation. Check label for sensitive varieties. *Snap beans and navy beans on coarse soils*: Do not exceed 3.5 pts. per acre. *All other labeled crops*: Do not exceed 9.75 pts. per acre.

MicroTech® at the following rates:

Lima beans: 2.5-3 qts. per acre.

Red kidney types of dry bean in Illinois only: 2.5-3 qts. per acre.

Apply before planting and incorporate. *RUP*.

Outlook® at 10-21 fl. oz. per acre. *Dry beans only*. Use lower rate on coarse soils that low in organic matter. Apply before planting and incorporate, apply after planting before emergence, or apply after planting when beans have 1-3 trifoliate leaves. Do not exceed 12 fl. oz. on coarse soils prior to emergence. 70-day PHI.

Pendimethalin products at the following rates:

3.3EC formulations: 1.2-3.6 pts. per acre.

Prowl H2O®: 1.5-3 pts. per acre.

Use low rates on coarse soils. Broadcast and incorporate before planting. Not effective on soils with high organic matter.

Sonalan® at 1.5-4.5 pts. per acre. *Dry beans only*. *Not for muck soils.* Apply and incorporate before planting. Use higher rates to suppress eastern black nightshade.

Trifluralin products at 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. Use lowest rate on coarse soils. Apply and incorporate before planting. Not effective on soils with high organic matter.

Preemergence Broadleaves

Recommended Products

Optill® at 1.5 oz per acre. *Peas and chickpeas only*. English peas (green shelled, snap, or snow peas) are labeled only in Illinois, Iowa, Minnesota, and Wisconsin. Apply preplant, preplant-incorporated or pre-emergence (up to 3 days after planting before cracking). Plant English and sugar snap peas at least 1/2-inch deep to avoid injury. Apply before cracking. Do not apply north of Highway 210 in Minnesota. Do not use on any *Phaseolus* bean species. Do not apply group 14, E herbicides within 30 days of planting.

Sharpen® at 0.75 fl oz. per acre. *Peas only*. Labeled for Illinois, Iowa, Minnesota, and Wisconsin. Apply preplant incorporated or pre-emergence (up to 3 days after planting before cracking) to suppress black nightshade, lambsquarters, pigweed, and velvetleaf. Plant English and sugar snap peas at least 1/2-inch deep to avoid injury. Do not apply group 14, E herbicides within 30 days of planting.

Spartan 4F® at 2.25-8 oz. per acre. *Dry peas and chickpeas only*. Labeled for Michigan, Minnesota, and Wisconsin.

Fall- or spring-apply early-preplant, preplant-incorporated, or pre-emergence. Rate depends on soil texture, organic matter, and pH. Do not use on soils with less than 1% organic matter or apply after crop emerges.

Spartan Advance® at 16-57 oz. per acre *Dry peas and chickpeas only*. Labeled for Michigan, Minnesota, and Wisconsin. Fall- or spring-apply early-preplant, preplant-incorporated, or pre-emergence. Rate depends on soil texture, organic matter, and pH. Do not use on sand soils with less than 1% organic matter or apply after crop emerges.

Spartan Charge® at the following rates:

Dry peas and chickpeas: 3-10.2 oz. per acre. Apply preplant-burndown, early-preplant, or pre-emergence. Do not use on coarse soils with less than 1% soil organic matter.

Dry beans in Minnesota only: 3.75-5.75 oz. per acre. Apply early-preplant or pre-emergence. Do not use on soils with less than 1.5% organic matter.

Rate depends on soil texture, organic matter, and pH. Do not apply after crop emerges.

Preemergence and Postemergence Broadleaves

Recommended Products

Permit® on *dry beans only* at the following rates:

Preemergence and postemergence broadcast or postemergence directed sprays: 0.5-0.66 oz. per acre.

Row middle applications: 0.5-1 oz. per acre.

Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply after planting but prior to soil cracking. Row-middle applications with no crop contact may be used after crop emergence. Do not exceed 1 oz. per acre per crop cycle, or 2 oz. per acre per 12-month period.

Pursuit® products at the following rates:

Cowpeas: **Pursuit 2L**® at 4 fl. oz. per acre, or **Pursuit DG**® at 1.44 oz. per acre.

Dry beans, lima beans, and peas: **Pursuit 2L**® at 3 fl. oz. per acre, or **Pursuit DG**® at 1.08 oz. per acre.

Snap beans in Illinois and Minnesota: **Pursuit 2L**® at 1.5 fl. oz. per acre.

All labeled crops in Minnesota north of Highway 210: **Pursuit 2L**® 2 fl. oz. per acre *only*, or **Pursuit DG**® at 0.72 oz. per acre *only*. Use 8 oz. of NIS per 25 gals. of spray solution if emerged weeds are present.

Snap beans in Illinois and Minnesota: Apply and incorporate within 1 week of planting, or apply within 1 day after planting. Apply before July 31. *All other labeled crops*: Apply and incorporate within 1 week of planting, or apply within 3 days after planting before crop emerges, or apply after beans have 1 fully expanded trifoliate leaf. Do not apply Pursuit® to fields treated with trifluralin or injury may occur. If N fertilizer is added to a postemergence application, Basagran® must be added to minimize crop injury. Refer to Basagran® label for rates. 30-day PHI for succulent peas and snap beans. 60-day PHI for all others.

Reflex® on *dry beans and snap beans only* at the following rates:

Extreme southeast Missouri: 1.5 pts. per acre per year (Region 5).

Indiana and Illinois south of I-70: 1.5 pts. per acre in alternate years (Region 4).

Indiana and Illinois north of I-70; and the rest of Missouri: 1.25 pts. per acre in alternate years (Region 3).

Kansas east of Highway 281 and Minnesota south of I-94: 1 pt. per acre in alternate years (Region 4).

Minnesota south of Highway 2 and north of I-94: 0.75 pt. per acre in alternate years (Region 5).

Not for lima beans. Reflex® is labeled in all states participating in this publication except in Kansas west of Highway 281 and in Minnesota north of Highway 2. Preemergence applications are labeled for all stated including Kansas east of Highway 281 and in Minnesota south of Interstate 94. Postemergence applications include Minnesota south of Highway 2 and Kansas east of Highway 281. The spectrum of weeds controlled varies by application method. For postemergence applications, apply when dry beans or snap beans have at least one fully expanded trifoliate leaf, and use NIS, COC, or other additives following label instructions. Do not use liquid nitrogen or ammonium sulfate as an additive. 30-day PHI for snap beans. 45-day PHI for dry beans.

Sandea® at the following rates:

Dry beans with preemergence and postemergence broadcast or postemergence directed sprays: 0.5-0.67 oz. per acre.

Dry beans with row middle applications: 0.5-1 oz. per acre.

Snap beans and lima beans preemergence or middle row applications: 0.5-1 oz. per acre.

Snap beans and lima beans postemergence: 0.5-0.67 oz. per acre.

Succulent peas preemergence: 0.5 oz. per acre. *Vigna species only: black-eyed pea, cowpea, southern pea.*

Succulent peas postemergence: 0.5-1 oz. per acre. *Vigna species only: black-eyed pea, cowpea, southern pea.* Directed sprays recommended.

Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Use lower rates on coarse soils with low organic matter. Apply after planting but prior to cracking. For postemergence

applications, apply to dry beans after plants have 1-3 trifoliate leaves but before flowering; apply to snap beans or lima beans after the crop has 2-4 trifoliate leaves but before flowering (directed spray may limit injury); and to *Vigna* spp. as a directed spray when plants have 3-4 trifoliate leaves but before flowering. Not recommended when temperatures are cool due to potential for crop injury. Row-middle applications with no crop contact may reduce crop injury after crop emergence. Do not exceed 0.67 oz. per acre per crop-cycle for dry beans, or 1 oz. per acre per crop-cycle for snap beans and succulent pea (*Vigna* spp. only). Do not exceed 2 oz. per acre per 12-month period. 30-day PHI.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Application Broadleaves and Grasses.

RR **Raptor**® at the following rates:

Dry beans (see label for specific types) and dry peas: 4 fl. oz. per acre. May add 1-2 gals. of COC, or 1 qt. of NIS plus 2.5 gals. of nitrogen or 12-15 lbs. ammonium sulfate per 100 gals. of spray solution to improve weed control (but may increase crop injury). If using COC or N fertilizer on dry beans to improve weed control, add Basagran® at 6-16 fl. oz. per acre or Rezult® at 12-24 fl. oz. per acre to minimize crop injury. You must add Basagran® or Rezult® for dry peas regardless of additives. A reduced 2 oz. per acre rate of Raptor® tank-mixed with Rezult® is labeled for control of mustard species in Minnesota for dry bean and dry peas. Do not exceed 1 application of Raptor® per year.

Lima beans (succulent) (IL, IN, IA, MI, MN, boot heel of MO, WI): 4 fl. oz. per acre. Must be applied with Basagran® at 6-16 fl. oz. per acre to improve crop tolerance. Apply when lima beans are in the first or second trifoliate and weeds are less than 3 inches. Do not apply during flowering. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution. Do not exceed 1 application per year.

Snap beans (IL, IN, IA, MI, MN, WI): 4 fl. oz. per acre. Must be applied with Basagran® at 6-16 fl. oz. per acre to improve crop tolerance. Apply after the first trifoliate is fully expanded and before bloom. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution. Do not add crop oils. Do not exceed 1 application per year.

Succulent (English) peas (IL, IN, IA, MI, MN, WI): 3 fl. oz. per acre. Apply to peas at least 3 inches tall but prior to 5 nodes before flowering. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution. Adding a nitrogen-based solution may improve weed control but may also increase crop injury. May add Basagran® at 6-16 fl. oz. per acre to improve crop safety and broadleaf weed control when using N-based fertilizer. The 3 oz. rate of Raptor® is weak on grasses. May use COC instead of NIS to improve activity on grasses, but always add Basagran® to improve crop safety when using COC. Using Raptor® on fields treated with trifluralin may increase the risk of injury. Do not exceed 1 application per year.

Postemergence Broadleaves

Recommended Products

Aim EC®. See details above for Burndown or Directed/Shielded Application Broadleaves.

Basagran 4L® at 1.5 to 2.0 pts. per acre, or **Basagran 5L**® at 1.2-1.6 pts. per acre. Apply when weeds are small and after peas have 3 pairs of leaves or first trifoliate leaf of beans is fully expanded. Do not add COC for peas. Do not exceed 4 pts. of 4L per acre per season. Do not exceed 3.6 pts. of 5L per acre per season. 30-day PHI .

Postemergence Grasses

Recommended Products

Assure II® at 5-12 fl. oz. per acre. *Dry beans, snap beans, and peas only*. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. 30-day PHI for succulent peas and dry beans. 15-day PHI for snap beans. 60-day PHI for dry peas.

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season.

Use low rates for annual grasses, and use high rates for perennial grasses. Apply to actively growing grass. 21-day PHI for crops harvested before they dry down. 30-day PHI for dry beans, dry lima beans, and dry peas.

Fusilade DX 2E® at 8-12 fl. oz. per acre. *Dry beans only*. Include 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 48 fl. oz. per acre per season. 60-day PHI.

Poast 1.5E® at 1-2.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4 pts. per acre per season. 15-day PHI for succulent beans and peas. 30-day PHI for dry beans and dry peas.

Targa® at 5-12 fl. oz. per acre. *Dry beans, snap beans, and peas only*. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. 30-day PHI for succulent peas and dry beans. 15-day PHI for snap beans. 60-day PHI for dry peas.

Herbicides for Legumes[1]

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop[2]				Incorporated	Timing Relative to Weeds		Weed Groups Controlled			Crops[3]					
		Before seeding	After seeding before emergence	Post emergence –between rows only	Postemergence		Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Dry Beans (*Phaseolus*)	Lima Beans	Snap Beans	Dry Peas	English Peas (including snap, snow)	Cowpeas
Aim EC® (12h/-)	carfentrazone	X	X	X				X		X	X	X	X	X	X	X	X
Assure II® (12h/15d to 60d)	quizalofop				X			X	X	X	X	X		X	X	X	
Basagran® (12h/30d)	bentazon				X			X		X	X	X	X	X	X	X	X
Command 3ME® (12h/45d)	clomazone	X	X				X		X	X	X		X	X	X	X	X
Dual Magnum ® (12h/-)	napropamide	X	X			Variable	X		X	X		X	X	X	X	X	X
Eptam® (12h/-)	EPTC	X		X		Yes	X		X	X		X		X			
Gramoxone Inteon 2L® (12h to 24h/-)	paraquat	X	X					X	X	X	X		X	X	X	X	
MicroTech®	alachlor	X				Yes			X			X	X				
Optill® (12h/-_	saflufenacil + imazethapyr	X	X				X	X		X	X				X	X	
Outlook® (12h/70d)	dimethenamid-P	X	X		X	Yes	X		X	X		X					
Pendimethalin	pendimethalin	X				Yes	X		X	X		X	X	X	X	X	X
Permit® (12h/30 to 60d)	halosulfuron		X	X	X		X	X		X		X					
Poast® (12h/15-30d)	sethoxydim				X			X	X			X	X	X	X	X	X
Pursuit® (12h/30d)	imazethapyr	X	X		X			X	X	X	X	X	X	X	X	X	X
Raptor® (4h/-)	imazamox				X			X	X	X	X	X	X	X	X	X	X
Reflex® (12h/30d to 45d)	Fomesafen				X			X		X	X	X		X			
Roundup®, others (12h/14d)	glyphosate	X	X	X				X	X	X	X	X	X	X	X	X	X
Sandea® (12h/30d)	halosulfuron)		X	X	X			X		X		X	X	X			X
Select Max®, others (12h/21-30d)	clethodim				X			X	X			X	X	X	X	X	X
Sharpen® (12h/-)	saflufenacil	X	X				X	X		X	X			X	X		
Sonalan®	ethalfluralin	X				Yes	X		X	X		X					
Spartan 4F® (12h/-)	sulfentrazone	X	X				X			X	X				X		
Spartan Advance® (12h/90d)	sulfentrazone + glyphosate	X	X				X	X	X	X	X				X		
Spartan Charge® (12h/-)	sulfentrazone + carfentrazone	X	X				X	X		X	X	X		X	X		
Targa® (12h/15d to 60 d)	quizalofop				X			X	X			X		X	X	X	
Treflan®, others (12h/-)	trifluralin	X				Yes	X		X	X		X	X	X	X	X	X

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted for at least one crop.
[3]X= permitted on this crop in at least one state.

Insect Control

Seed Corn Maggots

Plant seed that has been treated with a product containing diazinon, or Cruiser®.

Flies are attracted to rotting organic material and freshly plowed soil. Plow winter cover crop under early in the spring and thoroughly cover. Handle seeds carefully to prevent cracking.

Recommended Products

Capture LFR® at 0.2-0.39 fl. oz. per 1,000 ft. of row at planting.

Cruiser 5FS® or **Cruiser Maxx®**. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

Lorsban 4E® at 1.8 fl. oz. per 1,000 linear ft. of row. Apply at planting.

Wireworms

Recommended Products

Cruiser 5FS® or **Cruiser Maxx®**. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

Aphids and Leafhoppers

Potato Leafhopper Thresholds

Seedlings

0.5 per sweep, or 2 per row foot

3rd Trifoliate

1 per sweep, or 5 per row foot

Bud Stage

5 per row foot

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-10.5 fl. oz. per acre. Do not exceed 1 application per season. 21-day PHI.

Foliar applications: 1.2 fl. oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated vines. 3-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

RR **Assail 30SG®** at 2.5-5.3oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

Brigade 2EC® at 1.6-6.4 fl. oz. per acre, or **Brigade WSB®** at 4-16 oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. *RUP*.

Cruiser 5FS® or **Cruiser Maxx®**. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

Dimethoate 4E® or **Dimethoate 400®** at 0.5-1 pt. per acre. *Not for cowpeas*. Do not feed treated plants to livestock. Do not apply during bloom. 0-day PHI for Dimethoate 400® (mechanical harvest only). 2-day PHI for Dimethoate 4E®.

Di-Syston 8E® at 0.9 fl. oz. per 1,000 linear ft. of row for any row spacing, or at 1 pt. per acre. *Succulent legumes only*. Do not use treated vines for feed. Do not exceed 1 application per season. 60-day PHI. *RUP*.

Lannate SP® at the following rates:

Aphids: 0.5-1 lb. per acre.

Leafhoppers: 0.25-1 lb. per acre.

Do not feed hay to livestock for 7 days. 1-day PHI for succulent peas and succulent beans at 0.25-0.5 pts. 3-day PHI for succulent beans at high rate. 14-day PHI for dry beans. *RUP*.

M-Pede® at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

Mustang MAX® at the following rates:

Aphids: 3.2-4.0 oz. per acre.

Leafhoppers: 2.72-4.0 fl. oz. per acre.

Do not exceed 0.15 lb. a.i. per acre per season. 1-day PHI for succulent beans. 21-day PHI for dry beans.

RR **Movento®** at 4-5 fl. oz. per acre. *Aphids only*. 1-day PHI for succulent beans. 7-day PHI for dry beans.

Orthene 97® at 0.5-1 lb. per acre. Do not feed treated vines to livestock. 14-day PHI for snap beans and dry beans. 1-day PHI for lima beans.

Sevin XLR PLUS® at 0.5-1 qt. per acre. *Not for aphids*. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for forage. 21-day PHI for dry legumes.

Thimet 20G® at 4.5-7.0 oz. per 1,000 linear feet of row at any spacing. Drill granules to the side of the seed. Do not place granules in direct contact with seed. Do not feed bean foliage to livestock. 60-day PHI. *RUP*.

RR This is a reduced-risk pesticide. See page 34 for details.

Transform 50WG® at 0.75-1.5 fl. oz. per acre. *Aphids only.* Do not exceed 4 applications per season. 7-day PHI.

Warrior II® at 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Mexican Bean Beetles, Bean Leaf Beetles

Bean Leaf Beetle Threshold

1 beetle per foot of row

Mexican Bean Beetle Threshold

0.5 beetle per plant

Recommended Products

Asana XL® at 2.9-5.8 fl. oz. per acre. *Mexican bean beetle only*. *Not for bean leaf beetles*. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated vines. 3-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Baythroid® at 2.4-3.2 fl. oz. per acre. *Dry beans and peas only*. Do not exceed 6.4 fl. oz. or 4 applications per acre per season. Allow 14 days between applications. 3-day PHI for southern peas. 7-day PHI for dry beans. *RUP*.

Brigade 2EC® at 1.6-6.4 fl. oz. per acre, or **Brigade WSB**® at 4-16 oz. per acre. *Not for Mexican bean beetles*. Do not exceed 12.8 fl. oz. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. *RUP*.

Cruiser 5FS® or **Cruiser Maxx**®. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

Dimethoate 4E® or **Dimethoate 400**® at 0.5-1 pt. per acre. *Not for cowpeas*. Do not feed to livestock. Do not apply during bloom. 0-day PHI for Dimethoate 400® (mechanical harvest only). 2-day PHI for Dimethoate 4E®.

Di-Syston 8E® at 0.9 fl. oz. per 1,000 linear ft. of row for any row spacing, or 1 pt. per acre. *Not for bean leaf beetles*. Do not use treated vines for feed. Do not exceed 1 application per season. 60-day PHI. *RUP*.

Lannate SP® at 0.25-1 lb. per acre. *Not for bean leaf beetles*. Do not feed hay to livestock for 7 days. 1-day PHI for succulent peas and succulent beans at 0.75-1.5 pts. 3-day PHI for succulent beans at high rate. 14-day PHI for dry beans. *RUP*.

Mustang MAX® at 2.72-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent beans. 21-day PHI for dry beans.

Orthene 97® at 0.5-1 lb. per acre. Do not feed treated vines to livestock. 14-day PHI for snap beans and dry beans. 1-day PHI for lima beans.

Sevin XLR PLUS® at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for forage. 21-day PHI for dry legumes.

Thimet 20G® at 4.5-7.0 oz. per 1,000 linear ft. of row at any spacing. Drill granules to the side of the seed. Do not place granules in direct contact with seed. Do not feed bean foliage to livestock. 60-day PHI. *RUP*.

Warrior II® at the following rates:

Mexican bean beetle: 0.96-1.92 fl. oz. per acre.

Bean leaf beetle: 1.28-1.92 fl. oz. per acre.

Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Caterpillars (Alfalfa Caterpillars, Armyworms, Corn Earworms, Cutworms, European Corn Borers, and Loopers)

Recommended Products

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed treated vines to livestock. 3-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Baythroid® at 2.4-3.2 fl. oz. per acre. *Dry beans and peas only*. Do not exceed 6.4 fl. oz. per acre per season. Allow 14 days between applications. 3-day PHI for southern peas. 7-day PHI for dry beans. *RUP*.

Blackhawk® at 1.7-3.3 oz. per acre. 3-day PHI for succulent legumes. 28-day PHI for dry legumes.

Brigade 2EC® at 1.6-6.4 fl. oz. per acre, or **Brigade WSB**® at 4-16 oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. *RUP*.

Coragen® at 3.5-5 fl. oz. per acre. 1-day PHI.

Entrust® at 1-2 oz. per acre. 3-day PHI for succulent beans and peas. 28-day PHI for dry beans and peas.

Intrepid 2R® at 4-16 fl. oz. per acre. 7-day PHI.

Lannate SP® at 0.5-1 lb. per acre. Do not exceed 3 lbs. per acre per crop. 1-day PHI for peas. 5-day PHI for forage. 14-day PHI for hay. *RUP*.

Mustang MAX® at 1.28-4.0 fl. oz. per acre. Do not exceed 0.15 lb. a.i. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Orthene 97® at 0.75-1 lb. per acre. Do not feed treated vines to livestock. 14-day PHI for snap beans and dry beans. 1-day PHI for lima beans.

RR **Radiant SC**® at 3-8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 3-day PHI for succulent legumes. 28-day PHI for dry legumes.

Sevin XLR PLUS® at 1-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for fresh beans. 14-day PHI for forage. 21-day PHI for dry beans.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Cowpea Curculios, Pea Weevils (cowpeas)

Recommended Products

Asana XL® at 4.8-9.6 fl. oz. per acre. *Dry legumes only*. Do not exceed 38.4 fl. oz. per acre per season. Do not feed treated vines to livestock. 21-day PHI. *RUP*.

Baythroid® at the following rates:

Cowpea curculios: 1.6-2.4 fl. oz. per acre.

Pea weevils: 2.4-3.2 fl. oz. per acre.

Dry beans and peas only. Do not exceed 6.4 fl. oz. or 4 applications per acre per season. Allow 14 days between applications. 3-day PHI for southern peas. 7-day PHI for dry beans. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 2.72-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dried. *RUP*.

Sevin XLR PLUS® at 1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dry legumes.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Seed Corn Maggots

Plant seed that has been treated with diazinon or a lindane-diazinon combination.

Adult flies are attracted to rotting organic matter or freshly plowed soil.

Spider Mites

Recommended Products

Acramite 50WS® at 1-1.5 lbs. per acre. 3-day PHI.

Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. *Dry beans only.* 7-day PHI.

Dimethoate 4E® 0.5-1 pt. per acre. 0-day PHI.

Stink Bugs

Recommended Products

Baythroid® at 2.4-3.2 fl. oz. per acre. *Dry beans and peas only*. Do not exceed 6.4 fl. oz. or 4 applications per acre per season. Allow 14 days between applications. 3-day PHI for southern peas. 7-day PHI for dry beans. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. *RUP*.

Mustang MAX® at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes.

Sevin XLR PLUS® at 1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dried. *RUP*.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

Thrips (cowpeas)

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-10.5 fl. oz per acre. Do not exceed 1 application per season. 21-day PHI.

Foliar applications: 1.2 fl. oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

RR **Assail 30SG**® at 4.5-5.3 oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

Baythroid® at 1.6-2.1 fl. oz. per acre. *Dry legumes only*. Do not exceed 6.4 fl. oz. or 4 applications per acre per season. Allow 14 days between applications. 3-day PHI for southern peas. 7-day PHI for dry beans. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 3-day PHI. *RUP*.

Entrust® at 1.5-2 oz. per acre. 28-day PHI.

Mustang MAX® at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes.

RR **Radiant SC**® at 5-8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 3-day PHI for succulent legumes. 28-day PHI for dry legumes.

Sevin XLR PLUS® at 1 qt. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dry legumes.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP*.

RR This is a reduced-risk pesticide. See page 34 for details.

Mint

Peppermint and Spearmint Varieties

Peppermint: Black Mitcham, Robert's Mitcham, Todd's Mitcham, and Murray Mitcham. The latter three varieties are more resistant to verticillium wilt.

Spearmint: Scotch Spearmint and Native Spearmint. These two spearmints have distinctly different oils.

Planting and Rotation

Mints are grown from dormant runners (stolons) dug from existing fields in the late fall or spring. Because verticillium wilt disease is an important problem (even with the more resistant varieties), growers should always use disease-free planting stock. Certified and disease-free stocks are available. Also, careful fall plowing of established stands is important for both winter protection and for reducing the incidence of mint rust and other foliar diseases. "Squirrelly" mint, which occurs primarily on peppermint, is caused by the mint bud mite, *Tarsonemus pipermenthae*.

Although mints are perennials, stands should not be maintained longer than 3 or 4 years in a rotation program. Older stands may show serious build-ups of disease, insect, and weed problems.

Irrigation significantly increases oil yields both on muck and mineral soils, even in seasons with normal rainfall.

Fertilizing

For established mint, apply 120 to 150 pounds N per acre in split application (before emergence and before canopy closure). Potash and phosphorous should be maintained at 400 pounds K_2O per acre and 50 pounds P_2O_5 per acre.

Disease Control

Spearmint Rust, Septoria Leaf Spot

Recommended Products

Bravo®, **Echo**®, **Equus**®, and **Initiate**® are labeled for use at various rates. *Indiana only*. 80-day PHI.

Headline 2.09EC® at 9-12 fl. oz. per acre. *Rust only*. 14-day PHI.

Propimax EC® at 4 fl. oz. per acre. *Rust only*. 30-Day PHI.

RR **Quadris**® at 6.2-15.4 fl. oz. per acre. *Rust only*. 7-day PHI for processed mint.

Rally 40WSP® at 4-5 oz. per acre. *Rust only*. 30-day PHI.

Verticillium Wilt

Use wilt-resistant varieties of peppermint. Native spearmint is resistant.

Rotate plantings after no more than 3 or 4 years.

Weed Control

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Application

Recommended Products

Chateau WDG® at 2-3 oz per acre, or **Chateau SW**® at 4 oz per acre. Use NIS according to label instructions. Apply to established dormant mint. Tank mix with paraquat (see paraquat label for rates). Adding a nitrogen source will increase activity. Do not apply to frozen ground. Has residual soil activity. Do not exceed 4 oz. per acre in a single application or more than 8 oz. per acre in a single growing season. Make no more than 1 sequential application of Chateau® within 60 days of first application. Applying to nondormant mint may result in unacceptable injury. 80-day PHI.

Glyphosate products as a spot treatment in a 1-2% solution to actively growing weeds. The sprayed mint crop will be killed. Not all glyphosate formulations are labeled for mint. Apply as a spot treatment to no more than 10% of any acreage but can reapply to the same area at 30-day intervals. Avoid any drift to nontarget crops. 7-day PHI.

Paraquat products at the following rates:

Gramoxone Inteon 2L® at 2-3 pts. per acre. Do not exceed 3 pts. per acre.

Firestorm® at 1.3-2 pts. per acre. Do not exceed 2 pts. per acre.

Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before crop begins to grow in spring. *RUP.*

RR This is a reduced-risk pesticide. See page 34 for details.

Preemergence and Early Postemergence Broadleaves and Grasses

Recommended Products

Sinbar 80WP® at 1-2 lbs. per acre, or 0.25-0.5 lb. per acre plus NIS or COC postemergence to the crop and small weeds. Apply before mint emerges. Do not exceed 2 lbs. per acre per season. 60-day PHI.

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at 1.3 pts. per acre. Apply in spring before mint starts to grow. Do not apply to emerged mint. Do not exceed 1 application per season. Some whitening of tissue may occur as mint emerges. 84-day PHI.

Prowl H2O® at 1.5-4 pts. per acre. *Established mint only*. Use low rate on coarse soils. Apply to dormant mint before mint and weeds start to grow. 90-day PHI.

Trifluralin products at 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre, or 10G formulations at 5-7.5 lbs. per acre. Use low rate on coarse soils. Apply late winter or early spring, or in the fall after harvest when mint is dormant or semi-dormant. Incorporate or irrigate with 0.5 in. water.

Preemergence Broadleaves

Recommended Products

Spartan 75DF® at 3-6.7 oz. per acre. Apply to established mint when it is dormant — in the fall after post harvest cultivation, and/or in the spring after cultivation. For new mint, use 2.25-5 oz. per acre and apply before mint emerges. Rainfall or irrigation is required to move herbicide into the soil. Application may injure crop as mint emerges. Application to emerged mint will result in severe injury. Do not exceed 8 oz. per 12-month period.

Goal 2XL® at 2-3 qts. per acre in 20-40 gals. of water per acre. *Indiana only*. *Not for use on mineral or black sand soils.* Use 8 fl. oz. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply to dormant spearmint and peppermint on muck soil (greater than 20% organic matter) before weeds are 4 inches tall. Application to emerged mint will result in severe injury.

Postemergence Broadleaves

Recommended Products

Bentazon products at 0.5-1 lb. a.i. per acre. Use 4L formulations at 1-2 pts. per acre. Apply after mint and weeds have emerged. To control yellow nutsedge and Canada thistle, repeat application 7-10 days later. Crop oil will enhance activity. Do not exceed 4 pts. per acre per season.

Buctril 2E® at 1-1.5 pts. per acre in at least 10 gals. water per acre, or **Buctril 4EC**® at 8-12 fl. oz. per acre in at least 10 gals. water per acre. Apply before weeds have more than 4-6 leaves, and only on established mint that has been harvested at least one year prior to application. Buctril® may cause temporary stunting and chlorosis of mint. Do not apply to mint growing under stressful conditions, or when air temperatures are, or are expected to be, more than 70°F within 5 days of application. 70-day PHI.

Thistrol® at 1-2 pts. per acre.Apply in spring after mint emerges to suppress broadleaf weeds, or apply in fall to control winter annuals. May injure mint. Oil yields may be reduced if mint is more than 6 inches tall. Bindweed suppression is best with spring application when weeds are 6-8 inches long. 40-day PHI.

Stinger 3EC® at 0.33-1 pt. per acre. Use 4 fl. oz. of NIS per 25 gals. of spray solution. Apply up to 0.5 pt. in spring or up to 1 pt. in fall. Controls mainly composites and nightshade. To control Canada thistle in spring, apply before bud stage. Do not use mint straw, hay, or spent hay for compost or mulch and do not dispose of on land to be rotated to broadleaf crops due to herbicide remaining in mint hay or straw that will injure broadleaf plants. Do not exceed 1 pt. per acre per growing season. 45-day PHI.

Postemergence Grasses

Recommended Products

Assure II® at 8-12 oz. per acre. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 2 applications or 30 fl. oz. per acre per season. 30-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 2 applications per season. 20-day PHI.

Select Max® at 12-32 fl. oz. per acre, or **Select 2EC**® at 6-16 fl. oz. per acre Use 1 qt. of COC per 25 gals. of spray solution (1%v/v). Spray on actively growing grass. Use at least 16 fl. oz. Select Max®, or 8 fl. oz. of Select 2EC® on established mint. Wait at least 14 days between applications. 21-day PHI.

Insect Control

Cutworms, Loopers

Recommended Products

BP Various ***Bacillus thuringiensis*** formulations (Agree®, Biobit®, Dipel®, Javelin®, Lepinox®, etc.) are available. Follow label rates. 0-day PHI.

RR **Avaunt 30WDG**® at 3.5 oz. per acre. Do not exceed 14 oz. per acre per season. 7-day PHI.

Coragen® at 3.5-5 fl. oz. per acre. 3-day PHI.

Entrust® at 1.25-2 oz. per acre. 7-day PHI.

RR **Intrepid**® at 10-16 fl. oz. per acre. 14-day PHI.

Lannate SP® at 1 lb. per acre. Do not exceed 2 lbs. per acre per crop. 14-day PHI. *RUP*.

Lorsban 4E® at 2-4 pts. per acre, or **Lorsban 75WG**® at 1.33-2.67 lbs. per acre. Use lower rate when cutworm larvae are less than 0.75 inch long. Only 1 application per growing season. 90-day PHI.

Orthene 97® at 1 lb. per acre. Do not exceed 2 1/8 lbs. a.i. per acre per season. 14-day PHI.

RR **Radiant SC**® at 4-12 fl. oz. per acre. Do not exceed 39 fl. oz. per acre per season. 7-day PHI.

Flea Beetles

Recommended Products

RR **Actara**® at 1.5-3.0 oz. per acre. Do not exceed 12 oz. per acre per season. 7-day PHI.

Lannate SP® at 0.75-1 lb. per acre. For best results, apply immediately after harvest on stubble. Do not exceed 2 lbs. per acre per crop. 14-day PHI. *RUP*.

Malathion 5EC® at 1.5 pts. per acre. For best results, apply immediately after harvest on stubble. 7-day PHI.

Mites

Recommended Products

RR **Acramite 50WS**® at 0.75-1.5 lbs. per acre. Do not exceed 1 application per season. 7-day PHI.

Agri-mek 0.15EC® at 8-12 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. 28-day PHI. *RUP*.

Kelthane MF® at 1.75-2.5 pts. per acre. Do not exceed 1 application per season. 30-day PHI.

Zeal® at 2.4 oz. per acre. Do not exceed 1 application per season. 7-day PHI.

Varieties of mint grown for fresh market differ from those grown for processing.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

Okra

Varieties	Days to Maturity
Annie Oakley II (F1 Hybrid)	52
Clemson Spineless, (Open pollinated)	55
Burgundy (red)	60

Planting and Spacing

Seed 12 to 18 inches apart in rows 36 inches apart. Seed only after the soil has warmed to 65°F to 70°F for several days. Black plastic mulch with drip irrigation will increase yields. Transplants can be used for early production.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.5. Okra is very sensitive to low pH soils.

Preplant: N: 40 pounds N per acre preplant broadcast and disked in prior to seeding. P_2O_5: 0 to 200 pounds per acre. K_2O: 0 to 300 pounds per acre. Adjust according to soil type, previous management, and soil test results.

Sidedress N: Apply 40 pounds N as a sidedress after the first harvest.

Harvest

Okra should be harvested every 2 to 3 days to maintain optimal market size (2- to 4-inch long pods). Frequent harvesting increases overall yield since the plant will reset pods faster. Okra will yield 8,000 to 10,000 pounds per acre. Okra can be stored at 45°F to 55°F and 90 percent to 95 percent relative humidity for 7 to 10 days.

Disease Control

Fusarium Wilt

Avoid fields with a history of Fusarium wilt.

Rotations of several years may reduce Fusarium wilt severity.

Weed Control

Weeds in okra can be managed with cultivation and handweeding, plastic or other mulches, and herbicides. Because okra is a warm-season, transplanted crop, there should be enough time in the spring to prepare a stale seedbed before planting, which should reduce weed pressure in the crop. Herbicide choices are limited, and the products that can be broadcast do not control many broadleaf weeds, so it is important to include mechanical control in the weed management plan.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast at least 3 days before transplanting or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. 14-day PHI.

Burndown or Directed/Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply prior to transplanting or apply between crop rows with hooded sprayer. Do not apply before direct seeding. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season.

Preemergence Broadleaves and Grasses

Recommended Products

Dual Magnum® at 1-2 pts. per acre. *Indiana and Ohio only.* Apply to okra at least 4 inches tall before weeds emerge. Direct the spray to minimize contact with crop foliage, or apply only between crop rows. Do not incorporate. Do not exceed 2 pts. per acre or 1 application per crop per season. 60-day PHI.

Trifluralin products at 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting. Not effective on muck or high organic matter soils.

Preemergence Broadleaves and Nutsedge

Recommended Products

Sandea® at 0.5- 1 oz. per acre. Apply between rows of direct-seeded or transplanted crop. Use lower rates on coarse soils with low organic matter. Add 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Avoid contact of the herbicide with the crop. Avoid contact with surface of plastic mulch if present. Do not exceed 2 oz. per acre per 12-month period.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim EC®. See details above for Burndown or Directed/Shielded Applications Broadleaves.

Sandea®. See details above for Preemergence Broadleaves and Nutsedge.

Postemergence Grasses

Recommended Products

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5.5 pts. per acre per season. 14-day PHI.

Insect Control

Aphids

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-14 fl. oz. per acre. 21-day PHI.

Foliar applications: 10.5 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Closer 2SC® at 1.5-2 fl. oz. per acre. 1-day PHI.

Malathion 5EC® at 1.5 pts. per acre. 1-day PHI.

Colorado Potato Beetles

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-14 fl. oz. per acre. 21-day PHI.

Foliar applications: 10.5 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Entrust® at 1-2 oz. per acre. Do not exceed 9 oz. per acre per season. 1-day PHI.

Mustang Max® at 2.24-4 fl. oz. per acre. 1-day PHI.

RR **Radiant SC**® at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Corn Earworms

Recommended Products

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 7-day PHI.

Entrust® at 1-2 oz. per acre. Also controls European corn borers, hornworms, armyworms, and loopers. Do not exceed 9 oz. per acre per season. 1-day PHI.

Mustang Max® at 2.24-4 fl. oz. per acre. 1-day PHI.

RR **Radiant SC**® at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Sevin XLR PLUS® at 1-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI.

Mites

Recommended Products

RR **Acramite 50WS**® at 0.75-1.5 lbs. per acre. Do not exceed 1 application per season. 3-day PHI.

Zeal® at 2-3 oz. per acre. Do not exceed 1 application per season. 7-day PHI.

Potato Leafhoppers

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-14 fl. oz. per acre. 21-day PHI.

Foliar applications: 10.5 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Thrips

Recommended Products

Admire PRO® at the following rates:

Soil applications: 7-14 fl. oz. per acre. 21-day PHI.

Foliar applications: 10.5 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 7-day PHI.

Entrust® at 1.25-2.5 oz. per acre. Do not exceed 9 oz. of Entrust® per acre per season. 1-day PHI.

RR **Radiant SC**® at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Dry Bulb and Green Bunching Onion, Garlic, and Leek

ONION Varieties		
Bulbs	Early	Candy, Cavalier, Comanche, Norstar
	Main	Burgos, Copra, Lakota, Nitro, Spirit
	Late	Crusader, Daytona, Celtic, Sweet Sandwich, Spartan Banner 80, Walla Walla Sweet
Green		Beltsville Bunching

GARLIC Varieties	
Hardneck, Porcelain group	Georgian Crystal, Music
Hardneck, Rocambole group	Capathian, Spanish Roja
Hardneck, Purple Stripe group	Metechi, Persian Star
Softneck, Artichoke group	Inchelium Red
Softneck, Silverskin group	Idaho Silverskin

LEEK Varieties
Arkansas, Lancelot

Spacing

Onion: Raised beds with two double rows or wide rows spaced 14 inches apart on top of the bed with 12 seeds per foot within the wide (2 inches) row. Seed: 4 pounds per acre. Or transplant 4 inches apart in rows.

Garlic: Rows 12 to 36 inches apart with cloves 3 to 6 inches apart in the row. Plant bulbs 3 to 4 inches deep, with top of clove twice the depth of the clove height. For mechanical cultivation, plant flat side of clove perpendicular to the length of the row; for hand cultivation in dense plantings, plant angled side of clove parallel to the length of the row. Plant in fall 6 to 8 weeks before ground freezes.

Leek: Rows 14 to 18 inches apart with transplants 3 to 4 inches apart in the row.

Fertilizing

Onion, Garlic and Leek

Lime: Mineral soils: to maintain a soil pH of 6.0 to 6.8. Organic soils: lime if pH is less than 5.2.

Harvesting

Green onion: Harvest by pulling from soil after bulb base is thicker than a pencil but before bulbing. Optional undercutting can be used to make pulling easier. Remove dirty outer layer from bulb area. Trip roots. Trim tops as needed if allowed by state regulations. Green onions are usually sold in bunches. Harvest knob onions by pulling from soil when bulb has reached desired stage of development. Follow practices for green onions.

Dry bulb onion: Harvest dry bulb onions after tops have naturally fallen over. If a sprout inhibitor is used on storage onions, time application according to label instructions. Undercutting several days before harvest can improve keeping quality of storage onions. Dig from soil and dry in field or indoors at 75°F to 80°F and 70 percent to 80 percent relative humidity. Cut tops about 1 inch from bulb at harvest or after drying, or braid tops and hang onions to dry. Clean dry onions by gently brushing.

Leek: Harvest when stalk is 1 inch or more in diameter. Undercut plants, pull from soil, trim, and bunch.

Garlic: Harvest when tops have fallen over and partially dried. Lift from soil and dry protected from sun and rain. After drying, trim roots and remove tops, or leave tops on for braiding.

Onion and Leek

Preplant: N: for mineral soils, 70 pounds N per acre broadcast or applied to bed before planting for transplanted crops, or half broadcast preplant and half applied as a band 2 inches below the seed for direct seeded crops; for organic soils, 100 pounds N per acre broadcast and disked in. P_2O_5: 25 to 250 pounds per acre. K_2O: 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. At seeding, spray directly on the seed a solution of 2-6-0 at 1 pint per 100 feet of linear row. A 2-6-0 solution is equivalent to a 1:5 dilution of 10-34-0 liquid fertilizer with water. On muck soils with a pH greater than 6.0, add 1 pound of $MnSO_4$ per 1,000 feet of row at seeding, or use foliar Mn at the rate of 0.3 pound/100 gallons. Apply 2 to 3 times during the season starting 3 weeks after emergence.

Sidedress N: Mineral soils: 60 pounds N per acre to either side of the row at the 4- to 5-week stage of growth or by June 1. Muck soils: No sidedress N needed unless heavy rain occurs.

Garlic

N: 70 to 125 pounds N per acre total. Adjust according to soil organic matter content and cropping history.

Broadcast and incorporate 0 to 20 pounds N per acre before planting in the fall. Apply half the remainder when garlic begins to grow in the spring, and the rest in 1 to 2 sidedressings at 3-week intervals, ending 4 to 6 weeks before harvest. P_2O_5, 25 to 250 pounds per acre. K_2O: 0 to 250 pounds per acre. Adjust according to soil type, previous management and soil test results for your state. Broadcast and incorporate before planting in the fall.

Disease Control

Alternaria Purple Blotch and Botrytis Leaf Blight (all onion types)

Practice 3-4 year crop rotation. Rotation out of onions or related vegetables reduces the threat of these diseases in future onion crops.

Recommended Products

Aliette® at 2-3 lbs. per acre. *Purple blotch and dry bulb only*. 7-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. *Dry bulb only*. 7-day PHI.

Cabrio EG20® at the following rates:
Purple blotch: 8-12 oz. per acre.

Botrytis: 12 fl. oz. per acre (suppression only).

7-day PHI.

Dithane®, **Manzate**®, **Manex II**®, and **Penncozeb**® are labeled at various formulations. *Dry bulb only*. 7-day PHI.

Endura® 6.8 fl. oz. per acre. 7-day PHI.

RR **Fontelis**® at 16-24 fl. oz. per acre. 3-day PHI.

Merivon® at the following rates:

Botrytis leaf blight: 8-11 fl. oz. per acre.

Purple blotch: 4-11 fl. oz. per acre. 7-day PHI.

Omega 500® at 1 pt. per acre. 7-day PHI.

Pristine 38WG® at the following rates:
Botrytis leaf blight: 14.5-18.5 oz. per acre.

Purple blotch: 10.5-18.5 oz. per acre.

7-day PHI.

Rovral 4F® at 1.5 pts. per acre. *Dry bulb only*. 7-Day PHI.

RR **Quadris 2.08SC**® at the following rates:
Purple blotch: 6-12 fl. oz. per acre.

Botrytis leaf blotch: 9.0-15.5 fl. oz. per acre.

0-day PHI.

Quadris Opti® at 1.6-3.2 pts. per acre. *Green bunching only*. 14-day PHI.

RR **Reason**® at 5.5 fl. oz. per acre. *Purple blotch only*. 7-day PHI.

RR **Scala**® at 18 fl. oz. per acre (9 oz. per acre in tank mixes). 7-day PHI.

Satori® at the following rates:

Botrytis leaf blight: 9-15.5 fl. oz. per acre.

Purple blotch: 6-12 fl. oz. per acre.

0-day PHI.

Switch 62.5WG® at 11-14 oz. per acre. 7-day PHI.

Vangard WG® at 10 fl. oz. per acre. 7-Day PHI.

Bacterial Diseases (bacterial blight, slippery skin, sour rot, and bulb rot)

Use healthy seed. Rotate onion crops with crops from different families. Avoid overhead irrigation that might spread these diseases. Over fertilization with nitrogen can make the crop more susceptible. Applications of fixed copper products may reduce the spread of these diseases.

Annuals (emerged) — treatment applied before planting or crop emergence.

Botrytis Neck Rot (all types)

Windrow plants until neck tissues are dry before topping and storage. Cure rapidly and properly.

Artificial drying may be necessary (forced heated air at 93-95°F for 5 days).

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. *Suppression only*. *Dry bulb only*. 7-day PHI.

Botran 75W® at 1.67-3.3 lbs. per acre. *Dry bulb only*. 14-day PHI.

Omega 500® at 1 pt. per acre. 7-day PHI.

Downy Mildew

Cool wet conditions favor the development of this disease.

Recommended Products

Agri-Fos® at 2 qts. per acre. 0-day PHI.

Aliette® at 2-3 lbs. per acre. *Dry bulb only*. 7-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. *Suppression only*. 14-day PHI for green onion. 7-day PHI for dry bulb.

Cabrio EG20® at 12 oz. per acre. *Suppression only*. 7-Day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled for dry bulb. 7-day PHI.

Forum® at 6 oz. per acre. 0-day PHI.

Merivon® at 8-11 fl. oz. per acre. 7-day PHI.

Merivon SC2.09® at 8-11 fl. oz. per acre. *Suppression only.* Must have supplemental label. 7-day PHI.

Phostrol® at 2.5-3.75 pts. per acre. *Dry bulb only*. 0-day PHI

Presidio® at 3-4 fl. oz. per acre. 2-day PHI.

RR **Quadris 2.08SC**® flowable at 9.0-15.5 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 2.4-3.6 pts. per acre. 7-day PHI for dry bulb. 14-day for green onion.

RR **Reason**® at 5.5 fl. oz. per acre. 7-day PHI.

RR **Revus 2.09SC**® at 8 fl. oz. per acre. 7-day PHI.

Ridomil Gold Bravo SC® at 2.5 pts. per acre. 7-day PHI for dry bulb. 14-day PHI for green onion.

Zampro® at 14 fl. oz. per acre. 0-day PHI.

Fusarium Basal Rot

Use Fusarium-resistant varieties such as Elba Globe, Spartan Banner, and Harvestmore. Consult seed catalogues for varietal characteristics.

Smut

Recommended Products

Dithane®, **Manzate**®, and **Penncozeb**® at 3 lbs. per acre for dry formulations, or at 2.4 qts. per acre for flowable formulations.

White Rot (Sclerotium)

Recommended Products

Botran 75W® at 3-5.3 lbs. per acre. *Dry bulb only*.

Topsin M 70DF® at 2 lbs. per acre, or flowable formulations at 40 fl. oz. per acre.

Weed Control for Garlic and Dry Bulb Onion

Onions and related crops pose challenges for weed control because the narrow leaves of the crop provide little shade to suppress weed growth, and, except for green onions, the crops grow for several months. Designing bed and row spacing to fit equipment available for mechanical control will make weed management more efficient. When herbicides are used, multiple applications are often made. Other tools include careful cultivation and hoeing, the use of plastic mulch for transplants, organic mulches, and flame weeding. A flamer can be used to control weeds that emerge after seeding and before the crop emerges. Some growers also use flaming successfully over the top of young onions or garlic, or directed toward the bases of larger plants — even though some crop injury is likely with postemergent flaming.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2.5-4 pts. per acre. *Not for transplanted onions*. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before planting or after planting but before crop emergence. Do not exceed 4 pts. of Gramoxone Inteon 2L® or 2 pts. of Gramoxone Max 3L® per acre. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Broadcast before planting, after planting but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Postemergence Directed/Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Preemergence Broadleaves and Grasses

Recommended Products

Dual Magnum® at 0.67-1.3 pts. per acre. *Indiana and Ohio only.* Apply postemergence starting when the crop has 2 true leaves. For dry bulb onions, a second application may be applied 21 or more days after the first. *Garlic:* Do not exceed one application and 1.3 pts. per acre per season. 21-day PHI. *Dry bulb onions:* Do not exceed 1.3 pts. per acre per

RR This is a reduced-risk pesticide. See page 34 for details.

application and 2.6 pts. per acre per crop and two applications per crop. 60-day PHI.

Nortron SC® at 16-32 fl. oz. per acre. *Dry bulb onions only*. *Not for garlic*. Apply preemergence or soon after seeding before weeds germinate. May also be used postemergence, see below. Use on mineral soils only. Do not exceed 48 fl. oz. per acre per season on coarse soils and 96 fl. oz. per acre per season on medium and fine soils.

Outlook® at 12-21 fl. oz. per acre. Apply after crop plants have 2 true leaves. For transplants, apply after transplanting when soil has settled around plants. May be tank-mixed with other herbicides, see label. 30-day PHI.

Pendimethalin products. Use 3.3EC formulations at 1.2-3.6 pts. per acre, or Prowl H2O® at 1.5-3 pts. per acre. *Garlic*: apply after planting before crop and weeds emerge, and/or apply when garlic has 1-5 true leaves. *Dry bulb onions*: apply when onions have 2-9 true leaves. *Onions on muck soils only*: apply 3.3EC formulations at up to 4.8 pts. per acre, or Prowl H2O® at 4 pts. per acre after seeding and before crop emerges, after onions have 2 leaves, and if needed at 6-9 leaves. Do not exceed 14.4 pts. per acre of 3.3EC formulations or 12.5 pts. per acre of Prowl H2O® on muck soils. Use low rates on coarse soils. 45-day PHI.

Trifluralin products at 0.375-0.625 lb. a.i. per acre. Use 4EC formulations at 0.75-1.25 pts. per acre. *Dry bulb onions only*. *Not for garlic*. Use the lowest rate on coarse soils. Apply at layby as directed spray between onion rows and incorporate. Mineral soils only. 60-day PHI.

Preemergence Broadleaves

Recommended Products

Chateau WDG® at the following rates:

Garlic: 6 oz. per acre. Apply within 3 days after planting and before garlic emerges. Do not exceed 6 oz. per acre per growing season.

Dry bulb onions: 2 oz. per acre. Apply to transplanted onions between the 2- and 6-leaf stage or to direct-seeded onions between the 3- and 6-leaf stage. Will not control emerged weeds. Wait at least 14 days between applications.

Do not exceed 2 oz. per acre per application, or 3 oz. per acre per growing season. 45-day PHI for dry bulb onions.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. *Onions only*. Apply at seeding, transplanting, and/or layby. Preplant incorporation not recommended. May be sprayed over transplants.

Prefar 4E® at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting. Or apply after seeding, before crop emerges and irrigate within 24 hours. Mineral soils only.

Postemergence Broadleaves

Recommended Products

Buctril® products at the following rates:

Garlic: **Buctril 2EC**® at 1.5-2 pts. per acre, or **Buctril 4EC**® at 0.75-1 pt. per acre. Apply after garlic emerges and before it is 12 in. tall. 112-day PHI for garlic.

Onions: **Buctril 2EC**® at 1-1.5 pts. per acre, or **Buctril 4EC**® 0.5-0.75 pt. per acre for onions. Apply when onions have 2-5 true leaves, using 50-70 gals. of water per acre, or on muck soils east of the Mississippi River only, apply 3-4 days before onions emerge. To minimize onion injury apply after 2 days of sunny weather when onion leaves are dry and temperatures are 70-80°F.

Goal 2XL® at the following rates:

Seeded crops: 0.5 pt. per acre.

Transplanted crops: 1-2 pts. per acre. Use lower rate on coarse soils. Apply after direct-seeded crop has 2 true leaves, or prior to transplanting onions, or within 2 days after transplanting.

Do not exceed 2 pts. per acre. 45-day PHI for onions. 60-day PHI for garlic.

Postemergence Broadleaves and Grasses

Recommended Products

Nortron SC® at 16 fl. oz. per acre. *Dry bulb onions only*. *Not for garlic*. Apply postmergence up to 4 times, ending 30 days before harvest. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. Do not exceed 48 fl. oz. per acre per season on coarse soils and 96 fl. oz. per acre per season on medium and fine soils.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Garlic: **Select Max**® at 9-16 fl. oz. per acre, or **2EC formulations of clethodim products** at 6-8 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v).

Dry bulb onions: **Select Max**® at 12-32 fl. oz. per acre, or **2EC formulations of clethodim products** at 6-16 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v).

Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 2 applications per season for garlic or shallots. 45-day PHI for dry bulb crops.

Fusilade DX 2E® at 10-12 fl. oz. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Apply to small actively growing grass. Do not exceed 48 fl. oz. per acre. 45-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 30-day PHI.

Weed Control for Leek and Green Onion

Onions and related crops pose challenges for weed control because the narrow leaves of the crop provide little shade to suppress weed growth, and, except for green onions, the crops grow for several months. Designing bed and row spacing to fit equipment available for mechanical control will make weed management more efficient. When herbicides are used, multiple applications are often made. Other tools include careful cultivation and hoeing, the use of plastic mulch for transplants, organic mulches, and flame weeding. A flamer can be used to control weeds that emerge after seeding and before the crop emerges. Some growers also use flaming successfully over the top of young onions or garlic, or directed toward the based of larger plants — even though some crop injury is likely with postemergent flaming.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications

Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2.5-4 pts. per acre. *Direct-seeded onions only*. *Not for transplants or sets*. Use 1 qt. of COC, or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before planting or after planting but before crop emergence. Do not exceed 4 pts. of Gramoxone Inteon 2L® or 2 pts. of Gramoxone Max 3L® per acre. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Broadcast before planting, after seeding but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Premergence Broadleaves and Grasses

Recommended Products

Dual Magnum® at 0.67-1.3 pts. per acre. *Green onions in Indiana and Ohio only. Not for leeks*. Apply postemergence starting when the crop has 2 true leaves. Do not exceed one application and 1.3 pts. per acre per season. 21-day PHI.

Outlook® at 12-21 fl. oz. per acre. Apply after crop plants have 2 true leaves. For transplants, apply after transplanting when soil has settled around plants. May be tank-mixed with other herbicides, see label. 30-day PHI.

Prowl H2O® at 2 pts. per acre. *Use only on muck soils (organic matter greater than 20%) or on mineral soils with greater than 3% organic matter.* Apply after seeding before crop emerges, or apply when crop has 2 to 3 true leaves. If both pre and post applications are used, wait 30 days after preemergence application before applying postemergence. Do not exceed 2 pts. per acre per application or 4 pts. per acre per season. 30-day PHI.

Premergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. Apply at seeding, transplanting, and/or layby. Preplant incorporation not recommended. May be sprayed over transplants.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Buctril 2EC® at 1-1.5 pts. per acre, or **Buctril 4EC**® at 0.5-0.75 pt. per acre. *Onions only*. *Not for leeks*. Apply when onions have 2-5 true leaves, using 50-70 gals. of water per acre, or on muck soils east of the Mississippi River only, apply 3-4 days before onions emerge. To minimize onion injury apply after 2 days of sunny weather when onion leaves are dry and temperatures are 70-80°F.

Postemergence Grasses

Recommended Products

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use with 1 qt. COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 14-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 30-day PHI.

Herbicides for All Garlic, Onions, and Leeks[1]

		Timing and Application Location Relative to Crop[2]						Timing Relative to Weeds		Weed Groups Controlled			Crops[3]			
Product (REI/PHI)	Common Name	Before seeding	After seeding before emergence	Before transplanting	Post emergence -between rows only	Postemergence	Incorporated	Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Garlic	Onion, dry bulb	Onion, green	Leek
Aim EC® (12h/-)	carfentrazone								X		X	X	X	X	X	X
Buctril® (12h/112d)	bromacil		X		X	X			X		X	X	X	X	X	
Chateau® (24h/ 45d)	flumioxazin					X		X			X	X	X	X		
Dacthal W-75®, Dacthal® flowable (12h/-)	DCPA	X		X		X		X		X				X	X	X
Dual Magnum® (24h/21d)	s-metolachlor					X		X		X	X		X	X	X	
Fusilade® (12h/45d)	fluazifop					X			X	X			X	X		
Goal® (12h/45d to 60d)	oxyfluorfen			X		X			X			X	X	X		
Gramoxone Inteon 2L® (12h to 24h/-)	paraquat	X	X						X	X	X	X	X	*	*	
Nortron® (12h/)	norflurazon	X	X			X		X	X	X	X		X	X		
Outlook® (12h/30d)	dimethenamid-P					X		X		X	X	X	X	X	X	X
Prowl H2O® (24h/30d)	pendimethalin		X			X		X		X	X		X	X	X	X
Poast® (12h/30d)	sethoxydim					X			X	X			X	X	X	X
Prefar 4E (12/-)	bensulide	X	X	X			yes	X		X			X	X		
Roundup®, others (12h/)	glyphosate	X	X	X	X				X	X	X	X	X	X	X	X
Select Max®, others (12h/14d to 45d)	clethodim					X			X	X			X	X	X	X
Treflan®, others (12h/ 60d)	trifluralin				X		yes	X		X	X			X		

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted for at least one crop.
[3]X=may be used for that crop. *=Direct-seeded crops only.

Insect Control

Onion Maggots (dry bulb)

Recommended Products

FarMore FI500® commercial seed treatment.

Sepresto® commercial seed treatment is part of the CAPS treatment, which is available only on Nunhems varieties.

Lorsban 4E® at 1.1 fl. oz. per 1,000 linear ft. of row, or Lorsban 75WG® at 0.73 oz. per 1,000 linear ft. of row as an in-furrow drench. For furrow treatment at planting. Use a minimum of 40 gals. of total drench per acre. Limit of 1 application per year.

Onion Maggots (dry bulb and green bunching)

Recommended Products

Ambush 25W® at 6.4-19.2 fl. oz. per acre. *Adult control.* Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP.*

Diazinon AG500® at 2-4 qts. per acre, or Diazinon 50W® at 4-8 lbs. per acre. Broadcast just before planting and mix into the top 3-4 inches of soil. Apply in sufficient water to drench seed furrow planting. Do not exceed 3 foliar applications per season. 14-day PHI. *RUP.*

Mustang MAX® at 2.24-4.0 fl. oz. per acre. *Adult control.* Do not exceed 20 fl. oz. per acre per season. Add COC at 16 fl. oz. per acre. 7-day PHI. *RUP.*

Pounce 25WP® at 6.4-19.2 fl. oz. per acre. *Adult control.* Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP.*

Warrior® at 1.92-3.2 fl. oz. per acre. *Adult control.* Do not exceed 1.92 pts. per acre per season. 14-day PHI. *RUP.*

RR This is a reduced-risk pesticide. See page 34 for details.

Onion Thrips (dry bulb, green bunching, garlic, and leeks)

Field site selection. Onion thrips build to high levels in small grains and move to onions when small grains dry down or are harvested. Avoid planting next to small grains.

Plant resistant/tolerant varieties. Tolerant varieties include White Keeper, El Charro, Snow White, Vega, X201, and Zapotec.

Recommended Products

RR **Assail 30SG®** at 5-8 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Entrust® at 1.25-2.5 oz. per acre. 1-day PHI.

Exirel® at 13.5-20.5 fl. oz. per acre. 1-day PHI.

Movento® at 5 fl. oz. per acre. Do not exceed 2 applications per year. 3-day PHI.

Mustang MAX® at 2.88-4.0 fl. oz. per acre. Do not exceed 20 fl. oz. per acre per season. Add COC at 16 fl. oz. per acre. 7-day PHI. *RUP.*

RR **Radiant SC®** at 6-10 fl. oz. per acre. Do not exceed 30 fl. oz. per acre per season. 1-day PHI.

Onion Thrips (dry bulb and garlic)

Recommended Products

Ambush 25W® at 9.6-19.2 oz. per acre. Use when thrips first appear. *Not for rescue treatments.* Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP.*

Pounce 25WP® at 9.6-19.2 oz. per acre.

Warrior® at 2.56-3.84 fl. oz. per acre. Do not exceed 1.92 pts. per acre per season. 14-day PHI. *RUP.*

Onion Thrips (dry bulb and green bunching)

Recommended Products

Lannate SP® at 1 lb. per acre. Green onion: Do not exceed 6 lbs. per acre. *Dry bulb:* Do not exceed 4 lbs. per acre. 7-day PHI. *RUP.*

Using black plastic mulch with onions may warm the soil and help manage weeds.

Potato

Varieties	Season	Use	Scab Resistance	Appearance and Comments
Dark Red Norland	very early	market, home	good	Dark, deep red; smooth skinned; shallow eyes medium in number
Red Norland	very early	market, home	good	Bright red, oblong, smooth skinned, shallow eyes medium in number
Superior	early	chips, market	very good	White, slight russet, oval, very popular
Russet Norkotah	early	market, home	fair	Very good appearance, good baking quality, fair specific gravity
Cascade	mid-season	market, home	good	White, round
Goldrush	mid-season	market, home	fair	Very good appearance, good baking quality, fair specific gravity.
Snowden	mid-season	chips, market	good	White, very high dry matter, ideal for baking and French fries; exceptional ability to produce white potato chips; tubers sometimes rough
Atlantic	late	chips, market	good	White, blocky-round, high yield; hollow heart, internal browning, high specific gravity
Katahdin	late	market, home	fair	White, smooth, round, shallow-eyed
Kennebec	late	market, home	fair	White, long, oval
Red Pontiac	late	home garden	fair	Red, round, very high yield, low specific gravity, good boiling, mashing type
Russet Burbank				
For trial only				
Conestoga	early			A white type with good shelf life, shape, and baking quality
Somerset	mid-season			Blocky, very good appearance, high specific gravity, chips well, white
Yukon Gold	early	local market, home		Yellow flesh, good size
Russian Banana	late	specialty markets	good	Long, narrow fingerling; pale yellow flesh
Carola	late	specialty markets	good	Yellow skin and flesh, oval

Spacing

Rows 34 to 36 inches apart. Seed pieces 9 to 11 inches apart in row, depending on variety and intended use. Seed 16 to 18 100-pound bags per acre. Seed piece should be 1.5 to 2 ounces. Using B-size certified seed will save cutting labor and reduce tuber-borne diseases.

Fertilizing

Lime: To control common scab, soil pH should be within 5.0 to 5.2. However, low soil pH reduces phosphorus availability and increases availability of toxic elements such as manganese and aluminum. If the field has a history of scab, using scab-resistant varieties is recommended. Then, the soil pH can be 6.5 where phosphorus is most available.

Preplant: N: none — only a small amount such as 24 to 30 pounds with the starter fertilizer. P_2O_5: none — apply 50 to 150 pounds as a starter depending on the soil test results. K_2O: 50 to 400 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For the most efficient phosphate application, apply the fertilizer at planting in a band 2 to 3 inches to the side and below each side of the tuber. Examples would be 500 pounds per acre of 6-24-24 or 8-16-16. Do not apply more than 200 pounds of K_2O per acre in the band at planting. On sandy soils, broadcast 30 pounds or band 15 pounds sulfur per acre.

Sidedress N: For irrigated sandy soils, two split N applications are recommended: half at emergence and half at hilling or tuber initiation. For the early maturing varieties, use 50 to 60 pounds of N per acre at each

growth stage. The second application can be adjusted according to rainfall and a petiole nitrate-N analysis. For upland or finer textured soils, all of the required N can be applied preplant or shortly after emergence. For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, apply 100 pounds N per acre. For soils with less than 3 percent organic matter and the above rotation, apply 135 pounds N per acre. For potatoes following corn, rye, oats, wheat, or a vegetable crop, apply 150 pounds N per acre. Refer to University of Minnesota recommendations for N rates adjusted for yield goal.

Vine Killing

Vine Killing Product	Treatment	Comments
Defol 750®	3.2 qts. per acre in 10-20 gals. water by ground or 5-10 gals. by air.	Apply 10 days before harvest. Do not apply in extreme heat during middle of the day.
paraquat	0.8-1.5 pts. per acre of 2.5L or 0.6-1.0 pt. per acre of 3L in 50-100 gals. of water plus 1 gal. COC or 1-2 pts. nonionic surfactant per 100 gals. spray solution. **Not for potatoes to be stored or used for seed.**	Begin applications when leaves begin to turn yellow. Immature potato foliage and drought-stressed potato foliage are tolerant to this product. Maximum 3 pts. of 2.5L or 2 pts. of 3L per acre per season. For split applications, use lower rate and wait 5 days between applications. Read label for complete instructions. 3L formulation not for use in Iowa or Missouri. 3-day PHI.
Reglone®	1-2 pts. in 20-100 gals. water plus 8-64 fl. oz. nonionic surfactant.	A second application can be made if necessary. Allow at least 5 days between applications. 7-day PHI.
Rely 200®	29 fl. oz. per acre.	Do not make more than 1 application. 9-day PHI.

Chemical Sprout Control

Use maleic hydrazide (MH-30) according to label directions one week after blossoms fall. For varieties and conditions where flowering does not occur, apply four to six weeks before potatoes are mature and ready for harvest. Make only one application. Apply when no rain is expected for 24 hours. Potatoes treated with MH cannot be used for seed because sprouting will be inhibited. Follow label directions.

Disease Control

Black Dot

Recommended Products

Bravo®, Echo®, and **Equus®** and are labeled for use at various rates. 7-day PHI.

Headline SC® at 6-9 fl. oz. per acre. 3-day PHI.

Luna Tranquility® at 11.2 fl. oz. per acre. *Disease suppression only.* 7-day PHI.

Quadris® at 6-15.5 fl. oz. per acre. 14-day PHI.

Revus Top 2.08SC® at 5.5-7.0 fl. oz. per acre. 14-day PHI.

Satori® at 6-15.5 fl. oz. per acre. 14-day PHI.

Tanos® at 6-8 oz per acre. *Disease suppression only*. 14 day PHI.

Black Leg

Plant cut seed tubers that have been stored under conditions for rapid healing of cut surfaces and treated with a labeled potato seed treatment. Plant whole seed tubers where possible.

Black and Silver Scurf

Always use a crop rotation of 2-3 years. Plant seed pieces certified to be free of disease. Harvest potatoes as soon after maturity as possible. Use a fungicide when appropriate.

Recommended Products

Evolve® at 0.75 lb. per cwt.

Moncut® at 0.7-1.1 lbs. per acre.

RR **Quadris F®** at 0.4-0.8 fl. oz. per 1,000 row ft. in furrow.

Satori® at 0.4-0.8 fl. oz. per 1,000 row ft. in furrow.

Tops MZ® at 0.75 lb. per cwt.

Early Blight

Choose a cultivar with some resistance to early blight.

Avoid droughty, wet, or compacted soils, and other conditions (such as insufficient nitrogen) that might add undue stress to the crop and increase susceptibility to early blight. Rotate fields away from potato production for 2-3 years.

Group 11 Resistance

Strains of the fungus that cause early blight that are resistant to group 11 fungicides have been observed. Group 11 products labeled for potato and early blight include Gem®, Headline®, and Quadris®, and Satori®. See Table 32 (page 72) for more information.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. 7-day PHI.

Endura 70WG® at 2.5-4.5 oz. per acre. 10-day PHI.

Gavel 75DF® at 1.5-2 lbs. per acre. 14-day PHI.

RR **Gem 500SC**® at 2.9-3.8 fl. oz. per acre. 7-day PHI.

Headline® at 6-9 oz. per acre. 3-day PHI.

Luna Tranquility® at 11.2 fl. oz. per acre. 7-day PHI.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled for use at various rates. 14-day PHI.

RR **Quadris 2.08SC**® at 6.0-15.5 fl. oz. per acre. 14-day PHI.

Quadris Opti® at 1.6 pts. per acre. 14-day PHI.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 14-day PHI.

Rovral® at 1-2 pts. per acre 14-day PHI.

Satori® at 6-15.5 fl. oz. per acre. 14-day PHI.

RR **Scala**® at 7 fl. oz. per acre. 7-day PHI.

Tanos 50WDG® at 6 oz. per acre. 14-day PHI.

Fusarium Dry Rot

Avoid bruising at harvest. Cure potatoes in storage at 60°F before lowering temperature. Provide adequate ventilation.

Recommended Products

Mertect 340-F® at 0.42 oz. per 2,000 lbs. of tubers.

Late Blight

Destroy all potato cull piles.

The fungus that causes late blight does not overwinter in areas where hard freezes are characteristic. The fungus must be re-introduced on winds or plant material each year.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. 7-day PHI.

Curzate 60DF® at 3.2 oz. per acre. 14-day PHI.

Gavel 75DF® at 1.5-2 lbs. per acre. 14-day PHI.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled for use at various rates. 14-day PHI.

Omega 500F® at 5.5 fl. oz. per acre. 14-day PHI.

Previcur Flex® at 0.7-1.2 pts. per acre. 14-day PHI.

RR **Ranman 400SC**® at 1.4-2.75 fl. oz. per acre. 7-day PHI.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 14-day PHI.

Tanos 50 WDG® at 6-8 oz per acre. 14-day PHI.

Zampro® at 11-14 fl. oz per acre. 4-day PHI.

Ring Rot

Use certified disease-free seed. When cutting seed stock, the cutter should be periodically cleaned and disinfected, especially when changing seed lots.

The ring rot bacterium is easily spread. Although this bacterium will not survive more than 1 year in the soil (and thus can be controlled by crop rotation), a farm with ring rot must conduct a thorough clean-up before bringing in seed for the next year's crop. The organism can easily survive the winter in crop debris or soil on storage walls; seed cutters, bin pilers, graders, and other handling equipment; tractors, fork lifts and other vehicles; and on burlap sacks, wooden boxes, or other containers. If clean seed potatoes contact any of these contamination sources, the problem can recur.

The first step is to clean all contaminated surfaces with hot soapy water to remove all soil and debris. Use steam or water under pressure. However, this alone will not eliminate the bacterium. The surfaces then must be treated with a disinfectant.

For more information about sanitation, see *Commercial Greenhouse and Nursery Production: Sanitation for Disease and Pest Management* (Purdue Extension publication HO-250-W), available from the Education Store, www.the-education-store.com.

Root Knot and Lesion Nematodes

Sample fields during growing season for parasitic nematodes before planting. Avoid fields with high numbers of root knot and/or lesion nematodes. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate® gives adequate control when nematode populations are low to moderate. Vydate® and methyl bromide formulations are RUPs.

Scab

Plant resistant varieties. Maintain high moisture levels (near field capacity) during tuber set and enlargement. Do not apply manure or other organic matter immediately before planting. Avoid excessive liming, and maintain acid soil pH. Follow 3-4 year rotation schedule.

Seed Piece Decay

Plant seed pieces that are suberized. Warm seed tubers to 50°F before cutting; keep all equipment sanitized. Plant when soil temperatures are at least 45°F. Treat seed pieces with a registered fungicide when appropriate.

RR This is a reduced-risk pesticide. See page 34 for details.

Recommended Products

Dithane M45® at 1.25 lbs. per 50 gals. of water.

Evolve® or **Tops MZ**® at 0.75 lb per cwt.

Maxim® at 0.5 lb. per cwt.

Verticillium Wilt

Employ at least a 2-year rotation with small grains to manage fungus populations in the soil.

Good weed control also is important in reducing pathogen populations. Choose potato varieties that have partial resistance to Verticillium wilt.

Virus Diseases and Purple-Top Wilt (aster yellows)

Plant only certified seed tubers. Practice clean cultivation. Rogue first infected plants, including tubers. Control aphids and leafhoppers with insecticides.

White Mold

Avoid excess nitrogen. Reduce overhead irrigation if disease is present.

Recommended Products

Contans WG® at 2-4 lbs. in 50-100 gals. of water. Apply immediately after harvest or 3-4 months before planting.

Endura® at 5.5-10 oz. per acre. 10-day PHI.

Omega 500F® at 5.5-8 fl. oz. per acre. 14-day PHI.

Topsin FL® at 20-30 fl. oz. per acre. 21-day PHI.

Weed Control

Potato cultural practices offer several good opportunities to control weeds, beginning with the period between planting and emergence (when early-emerging weeds can be killed with an herbicide or flaming), and continuing through the hilling process (when weeds can be buried or cultivated out). Some organic farmers also use flaming after potatoes emerge because some injury to the potato foliage early in the season can be tolerated. A relatively large number of herbicides are labeled for use on potatoes.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 1-2 pts. per acre. Use 1 qt. of COC, or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before planting, or after planting but before ground cracks. *RUP*.

RR **Glyphosate** products at 0.75-2.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before planting, after planting before ground cracks, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Burndown or Directed/Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours of planting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. 7-day PHI.

Preemergence Broadleaves and Grasses

Recommended Products

Dual Magnum® or **Dual II Magnum**® at 1-2 pts. per acre. Use lower rates on coarse soils. Apply and incorporate before planting, or apply after planting before weeds emerge. May also be applied at 1.67 pts. per acre after hilling. Dual Magnum® might delay maturity and/or reduce yield of Superior and other early maturing varieties if cold, wet soil conditions occur after treatment. Dual Magnum® can be tank-mixed with Lorox®, Sencor®, Prowl® or Eptam®. See labels. Do not exceed 3.6 pts. per acre. 60-day PHI if applied before drag-off. 40-day PHI if applied at lay-by.

Eptam 7E® at 3.5-7 pts. per acre, or **Eptam 20G**® at 15-20 lbs. per acre. Apply before planting, after drag-off, or as directed spray at lay-by. Incorporate immediately. On muck soils, supplement with linuron or metribuzin products applied before crop emerges and after drag-off. The Superior variety may be sensitive. Suppresses nutsedge. 45-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Linuron® 50DF products at 1.5-3 lbs. per acre, or 4L products at 1.5-4 pts. per acre. Also controls small, emerged weeds. Apply after planting but before crop emergence, when weeds are less than 2 inches tall. Seed pieces must be planted at least 2 inches deep. Do not use on sand, loamy sand, or soils with less than 1 percent organic matter.

Matrix 25DF® at 1-1.5 oz. per acre. Typically combined with full-labeled rates of metribuzin to improve spectrum of broadleaf control. Use 0.5 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply after planting before crop emerges, at hilling, drag-off, or reservoir tillage, to a clean, newly prepared seedbed. Apply post when weeds are less than 1 inch tall. Avoid using adjuvants when potatoes are under heat stress. Do not exceed 2.5 oz. per acre per year. 60-day PHI.

Metribuzin® 4F products at 0.5-2 pts. per acre, or 75DF products at 0.33-1.32 lbs. per acre. *Not for early-maturing or red-skinned varieties.* Apply after planting before crop emerges, or apply up to 1 pt. of metribuzin 4F (1.32 lbs. of 75DF formulations) after emergence. Check label for sensitive varieties. Avoid spraying when potatoes are 12-15 inches tall. Do not apply within 3 days of cool, wet, or cloudy weather, or crop injury may occur. Do not apply within 1 day of other pesticide applications. Do not exceed 2 pts. of 4F formulations or 1.32 lbs. of 75DF formulations per acre per year. 60-day PHI.

Outlook® at 12-21 fl. oz. per acre. Apply after planting or drag-off and before weeds emerge. In cold and wet conditions potatoes may emerge slowly or be stunted. May be tank-mixed with a number of other potato herbicides. 40-day PHI.

Pendimethalin products at the following rates:

3.3EC formulations at 1.2-3.6 pts. per acre.

Prowl H2O® at 1.5-3 pts. per acre.

Use low rates on coarse soils. Broadcast after planting but before emergence or drag-off, or after potatoes have fully emerged before potatoes are 6 inches tall. May be incorporated. Not effective on muck soils. Do not apply postemergence to stressed potatoes.

Trifluralin products at 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre, or 60DF formulations at 0.8-1.7 lbs. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate after planting but before emergence, immediately after drag-off, or after potatoes have fully emerged. Not effective on muck or high organic matter soils.

Preemergence Broadleaves

Recommended Products

Chateau 51WDG® at 1.5 oz. per acre to soil covered potato. *Minnesota only*. Apply to potatoes after hilling. A minimum of 2 inches of soil must cover vegetative plant parts when applied to avoid injury. Provides suppression of lambsquarters, nightshades, pigweeds, wild mustard, and wild radish. Tank-mixes recommended to improve efficacy. No PHI listed.

League® at 4-6.4 oz. per acre. Apply after planting crop and before crop emerges, or immediately after hilling. Or use 3.2 oz. per acre and after at least 21 days make a second application of 3.2 oz. per acre to to control emerged weeds less than 3 inches tall. Or use 3.2-4 oz. per acre after crop emerges and before weeds are 3 inches tall; combine this with other measures to achieve satisfactory control. When emerged weeds are present use a Valent-recommended surfactant. Use the high rate in fields with a known history of nutsedge. Do not exceed two applications and 6.4 oz. per acre per year. 45-day PHI.

Reflex® at 1 pt. per acre. Broadcast after planting and before potatoes emerge. When using on any variety for the first time, first determine whether the variety is tolerant to this herbicide. May be tank-mixed with other preemergence herbicides. May not be used on the same land the following year. Alfalfa and most vegetables should not be planted for 18 months. 70-day PHI.

Postemergence Broadleaves and Grasses

Recommended Products

Linuron products. See details See details above for Preemergence Broadleaves and Grasses.

Matrix 25DF®. See details above for Preemergence Broadleaves and Grasses.

Postemergence Broadleaves

Recommended Products

Aim EC® See details above for Burndown or Directed/ Shielded Applications Broadleaves.

League®. See details above for Preemergence Broadleaves.

Metribuzin products. See details above for Preemergence Broadleaves and Grasses.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-32 fl. oz. per acre.

2EC formulations of clethodim products at 6-16 fl. oz. per acre.

Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

Poast 1.5E® at 1-2.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. 30-day PHI.

Prism 0.94EC® at 12.8-34 fl. oz. per acre. Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

Herbicides for Potatoes[1]

		Timing and Application Location Relative to Crop[2]						Timing Relative to Weeds		Weed Groups Controlled			
Product (REI/PHI)	Common Name	Before planting	After planting before grounds cracks	At/after Drag-off	At/after hilling	Between rows, directed/shielded	Postemergence over potato crop	Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Comments
Aim® (12h/-)	carfentrazone	X				X			X		X	X	
Chateau® (12h/-)	flumioxazin				X			X			X	X	Minnesota only.
Dual (II) Magnum® (12h/40d to 60d)	s-metolachlor	X	X	X	X			X		X	X		
Eptam® (12h45d)	EPTC	X		X		X		X		X			Incorporate.
Gramoxone Inteon® (12h to 24h/-)	paraquat	X	X						X	X	X	X	
League® (12h/45d)	imazosulfuron		X		X		X	X	X		X	X	
Linuron products (12h/-)	linuron		X					X	X	X	X	X	
Matrix® (4h/60d)	rimsulfuron		X	X	X			X	X	X	X	X	
Metribuzin products (12h/60d)	metribuzin		X				X	X		X	X	X	Not for sensitive varieties.
Outlook® (12h/40d)	dimethenamid-P		X	X				X		X	X		
Pendimethalin products (12h/ -)	pendimethalin		X				X	X		X	X		
Poast® (12h/30d)	sethoxydim	X	X	X	X		X		X	X			
Reflex® (12h/70d)	fomesafen		X					X			X	X	
Roundup®, others (12h/14d)	glyphosate	X	X			X			X	X	X	X	
Select Max®, others (12h/30d)	clethodim	X	X	X	X		X		X	X			
Treflan®, others (12h/-)	trifluralin		X	X				X		X	X		Incorporate.

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted on label.

Insect Control

Aphids (green peach aphid, melon aphid, potato aphid, and others)

Conserve natural enemies. Limiting insecticide use will conserve predators and parasites that help control aphid populations.

Recommended Products

Seed-applied or seed piece treatment materials:

Admire PRO® at 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect 70-90 days of control. Do not exceed 0.31 lb. a.i. per acre per season.

Cruiser 5FS® or **Cruiser Maxx**®. Rates vary according to seeding rate and row spacing. See labels. For best results plant potatoes immediately after treatment.

RR **Platinum 2SC**® at 5-8 fl. oz. per acre, or **Platinum Ridomil Gold**® at 2.2 fl. oz. per 1,000 linear ft. of row. Apply directly to seed piece in sufficient water to cover entire seed piece. Do not exceed 8 fl. oz. of Platinum 2SC®, or 38 fl. oz. of Platinum Ridomil Gold® per acre per season. Can expect 90-100 days control.

Foliar-applied materials:

RR **Actara**® at 3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.

Admire PRO® at 1.2 fl. oz. per acre. Do not exceed 3.7 fl. oz. per acre per season. 7-day PHI.

RR **Assail 30SG**® at 2.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

Belay® at 2-3 fl. oz. per acre. 14-day PHI.

Beleaf 50SG® at 2-2.9 oz. per acre. 7-day PHI.

Dimethoate 400® or **Dimethoate 4E**® at 0.5-1 pt. per acre, or **Dimethoate 2.67EC**® at 0.75-1.5 pts per acre. 14-day PHI for Dimethoate 400®. 0-day PHI for Dimethoate 2.67EC®. 2-day PHI for Dimethoate 4E®.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. Do not exceed 4 qts. per acre per season. Do not use after July 31, 2015. 7-day PHI.

RR **Fulfill**® at 2.75-5.5 oz. per acre. Requires up to 7 days to see results. Best control achieved with more than 10 gals. of water per acre. Do not exceed 5.5 oz. per acre per season. 14-day PHI.

Lannate SP® at 0.5-1 lb. per acre. Do not exceed 5 lbs. per acre per season. 6-day PHI. *RUP*.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

Monitor 4® at 1.5-2 pts. per acre. *Not for melon aphids*. Do not exceed 8 pts. per acre per season. 14-day PHI. *RUP*.

RR **Movento**® at 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. 7-day PHI.

Thimet 20G® at the following rates:

Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).

Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface, or in the seed furrow. 90-day PHI. *RUP*.

Torac® at 17.21 fl. oz. per acre. Do not exceed 2 applications per season. 14-day PHI.

Transform 50WG® at 0.75-1.5 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Vydate C-LV® at 17-33 fl. oz. per acre, or **Vydate L**® at 2-4 pts. per acre. Do not exceed 198 fl. oz. of Vydate C-LV® or 24 pts. of Vydate L® per acre per season. 7-day PHI. *RUP*.

Colorado Potato Beetles

Allowable Defoliation From Colorado Potato Beetles

Preflowering: 20-30%.

Flowering: 5-10%.

Tuber Formation: 30%.

Manage resistance. See Colorado Potato Beetle Resistance Management on page 178.

Practice crop rotation. Planting fields as far as possible from last year's potato fields will reduce potato beetle damage.

Regular (weekly) field scouting will allow you to determine the necessity for, and improve the timing of, insecticide treatments.

Colorado Potato Beetle Resistance Management

In some areas of the Midwest, Colorado potato beetle populations are resistant to many insecticides. If a previously effective insecticide is no longer effective, consider switching to another chemical class. If insecticides are still effective, alternating between classes will help prolong their effective lives. If planting time applications of neonirotinoids (Admire®, Gaucho®, Genesis®, Platinum®) are used, foliar neonirotinoids (Actara®, Leverage®, Provado®) should not be used.

The following table shows the active ingredients and chemical classes of Colorado potato beetle insecticides, and should be used to make resistant management decisions. To avoid promoting insect resistance, make sure to rotate between products that have different Insecticide Resistance Action Committee (IRAC) Group Numbers.

Insecticide	Active Ingredient	Chemical Class	IRAC Group Number
Actara®	thiamethoxam	neonicotinoid	4A
Platinum®	thiamethoxam	neonicotinoid	4A
Admire Pro®	imidacloprid	neonicotinoid	4A
Assail®	acetamiprid	neonicotinoid	4A
Belay®	clothianidin	neonicotinoid	4A
Genesis®	imidacloprid	neonicotinoid	4A
Gaucho®	imidacloprid	neonicotinoid	4A
Leverage®	imidacloprid + cyfluthrin	neonicotinoid + pyrethroid	4A + 3
Baythroid®	cyfluthrin	pyrethroid	3
Ambush®	permethrin	pyrethroid	3
Pounce®	permethrin	pyrethroid	3
Warrior II®	lambda cyhalothrin	pyrethroid	3
Agri-Mek®	abamectin	GABA agonist	6
Epi-Mek®	abamectin	GABA agonist	6
Monitor®	methomidaphos	organophosphate	1B
Endosulfan®	endosulfan	cyclodiene	2A
Kryocide®, Cryolite®	sodium aluminofluoride	mineral	9A
M-Trak®, Novodor®, Raven®	*Bacillus thuringiensis*	bacterium	11C
Entrust®	spinosad	spinosyn	5
Radiant®	spinetoram	spinosyn	5
SpinTor®	spinosad	spinosyn	5
Coragen®	chlorantraniliprole	anthanilic diamide	28
Voliam Flexi®	chlorantraniliprole + thiamethoxam	anthanilic diamide + neonicotinoid	28 + 4A
Voliam Xpress®	chlorantraniliprole + lambda cyhalothrin	anthanilic diamide = pyrethroid	28 + 3

Recommended Products

Soil-applied or seed piece treatments:

Admire PRO® at 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect good control of first generation potato beetle and 70-90 days of aphid control. Do not exceed 0.31 lb. a.i. per acre per season.

Cruiser 5FS® or **Cruiser Maxx®**. Rates vary according to seeding rate and row spacing. See labels. For best results plant potatoes immediately after treatment.

RR **Platinum®** at 5-8 fl. oz per acre, or **Platinum Ridomil Gold®** at 2.2 fl. oz. per 1,000 linear ft. of row. Apply directly to seed piece in sufficient water to cover entire seed piece. Provides seasonlong control of potato beetles and aphids at higher label rates. Do not exceed 8.0 fl. oz. of Platinum 2SC®, or 38 fl. oz. of Platinum Ridomil Gold® per acre per season.

Thimet 20G® at the following rates:

Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).

Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. *RUP*.

Vydate C-LV® at 8.5-33 fl. oz. per acre, or **Vydate L**® at 1-4 pts. per acre. Do not exceed 198 fl. oz. of Vydate C-LV® or 24 pts. of Vydate L® per acre per season. 7-day PHI. *RUP*.

Foliar-applied products:

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.

Admire Pro® at 3.7 fl. oz. per acre. Do not exceed 5.6 fl. oz. per acre per season.

Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 14-day PHI. *RUP*.

Ambush 25W® at 3.2-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP*.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. *RUP*.

RR **Assail 30SG**® at 1.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

RR **Avaunt 30WDG**® at 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. 7-day PHI.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Blackhawk® at 1.7-3.3 oz. per acre. 7-day PHI.

RR **Coragen**® at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz per acre per season. 14-day PHI.

Endosulfan 3EC® at 0.67-1.33 qt. per acre. Do not exceed 4 applications or 2.66 qts. per acre per season. Do not use after July 31, 2015. 7-day PHI.

Entrust® at 1-2 oz. per acre. Do not exceed 6.5 oz. per acre per season. Observe resistance management restrictions. 7-day PHI.

Kryocide® at 10-12 lbs. per acre. Apply by air in 5-15 gals. of water per acre, or by ground in 25-100 gals. of water per acre at a minimum of 7-day intervals. Do not exceed 96 lbs. per acre per season. 0-day PHI.

Monitor 4® at 1.5-2 pts. per acre. Do not exceed 8 pts. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 1.76-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

BP **Novodor**® at 1-3 qts. per acre. *Small Colorado potato beetle larvae only*. *Bacillus thuringiensis*-based insecticide. 0-day PHI.

Pounce 25WP® at 6.4-12.6 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP*.

Prokil Cryolite 96® at 10-12 lbs. per acre, or **Prokil Cryolite 50D**® at 19-23 lbs. per acre. Apply by air in 5-15 gals. of water per acre, or by ground in 25-100 gals. of water per acre at a minimum of 7-day intervals. Do not exceed 96 lbs. of Prokil Cryolite 96® per acre per season. Do not exceed 184 lbs. Prokil Cryolite 50D® per acre per season. 0-day PHI.

RR **Radiant SC**® at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre. 14-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Torac® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Warrior II® at 14-21 fl. oz. per acre. Do not exceed 2 applications per season. 14-day PHI.

Cutworms

Recommended Products

Ambush 25W® at 3.2-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP.*

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Lannate SP® at 0.5 lb. per acre. Do not exceed 5 lbs. per acre per season. 6-day PHI. *RUP*.

Monitor 4® at 1.5-2 pts. per acre. Do not exceed 8 pts. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 1.28-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Pounce 25WP® at 6.4-12.8 fl. oz. per acre. 14-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Warrior® at 1.92-3.20 fl. oz. per acre. Do not exceed 15.36 fl. oz. per acre per season. 7-day PHI.

European Corn Borers

European Corn Borer Threshold

1 egg mass per 25 leaves

Recommended Products

Ambush 25W® at 3.2-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP*.

RR **Avaunt 30WDG**® at 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. 7-day PHI.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 6 applications or 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Blackhawk® at 1.7-3.3 oz. per acre. 7-day PHI.

RR **Coragen**® at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz per acre per season. 14-day PHI.

Endosulfan 3EC® at 1.0-1.33 qts. per acre. Do not exceed 4 applications or 2.66 qts. per acre per season. Do not use after July 31, 2015. 7-day PHI.

Entrust® at 1-2 oz. per acre. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 7-day PHI.

Monitor 4® at 1.5-2 pts. per acre. Do not exceed 8 pts. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 1.76-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

Pounce 25WP® at 6.4-12.8 per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI.

RR **Radiant SC**® at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre. 14-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Flea Beetles

Flea Beetle Threshold

2 per sweep

Recommended Products

RR **Actara**®*, **Admire**®, **Asana**®, **Ambush**®, **Assail**®*, **Baythroid**®, **Endosulfan**®, **Kryocide**®, **Monitor**®, **Mustang Max**®, **Platinum**®*, **Pounce**®, or **Vydate**® can be applied as described for Colorado potato beetles. *Reduced-risk pesticide. Be sure to check PHI on product labels.

Cruiser 5FS® or **Cruiser Maxx**®. Rates vary according to seeding rate and row spacing. See labels. For best results, plant potatoes immediately after treatment.

Lannate SP® at 0.5 lb. per acre. Do not exceed 5 lbs. per acre per season. 6-day PHI. *RUP*.

Sevin XLR PLUS® at 0.5-1 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Thimet 20G® at the following rates:

Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).

Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. *RUP*.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Potato Leafhoppers

Recommended Products

Soil-applied or seed piece treatment materials:

Admire PRO® at 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect 40-50 days of control. Do not exceed 0.31 lb. a.i. per acre per season.

Cruiser 5FS® or **Cruiser Maxx**®. Rates vary according to seeding rate and row spacing. See labels. For best results, plant potatoes immediately after treatment. *RUP*.

RR **Platinum 2SC**®* at 5-8 fl. oz. per acre, or **Platinum Ridomil Gold**® at 2.2 fl. oz. per 1,000 linear ft. of row. **Reduced-risk pesticide.* Apply directly to seed piece in sufficient water to cover entire seed piece. Do not exceed 8 fl. oz. of Platinum 2SC®, or 38 fl. oz. of Platinum Ridomil Gold® per acre per season. Can expect 90-100 days control.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Thimet 20G® at the following rates:

Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).

Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. *RUP*.

Foliar-applied materials:

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. 14-day PHI.

Admire Pro® at 1.3 fl. oz. per acre. Do not exceed 5.6 fl. oz. per acre per season.

Ambush 25W® at 6.4-12.6 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP*.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. *RUP*.

RR **Assail 30SG**® at 1.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Dimethoate 400® or **Dimethoate 4E**® at 0.5-1 pt. per acre, or **Dimethoate 2.67EC**® at 0.75-1.5 pts per acre. 14-day PHI for Dimethoate 400®. 0-day PHI for Dimethoate 2.67EC®. 2-day PHI for Dimethoate 4E®.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. Do not exceed 4 applications per season. 7-day PHI.

Lannate SP® at 0.5-1 lb. per acre. Do not exceed 5 lbs. per acre per season. 6-day PHI. *RUP*.

Monitor 4® at 1.5-2 qts. per acre. Do not exceed 8 pts. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 1.76-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

Pounce 25WP® at 6.4-12.6 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. *RUP*.

Sevin XLR PLUS® at 0.5-1 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Torac® at 14-21 fl. oz. per acre. Do not exceed 2 applications per season. 14-day PHI.

Transform 50WG® at 1.5-2.25 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Vydate C-LV® at 17-33 fl. oz. per acre, or **Vydate L**® at 2-4 pts. per acre. Do not exceed 198 fl. oz. of Vydate C-LV® or 24 pts. of Vydate L® per are per season. 7-day PHI. *RUP*.

Warrior II® at 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Wireworms

Site selection: wireworms are most likely to be a problem in fields recently planted to sod or pasture, or in fields that have had a grassy weed problem.

Sampling: check for the presence of wireworms by burying a potato 6 inches deep in 5 locations per field prior to planting. Mark the spots with flags. Dig up the potatoes and inspect for wireworms 7 days later.

Recommended Products

Admire PRO® at 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect 70-90 days of control. Do not exceed 0.31 lb. a.i. per acre per season.

Brigade 2EC® at 9.6-19.2 fl. oz. per acre at planting. 21-day PHI.

Capture LFR® at 12.75-25.5 fl. oz. per acre at planting.

Cruiser 5FS® or **Cruiser Maxx**®. Rates vary according to seeding rate and row spacing. See labels. For best results plant potatoes immediately after treatment.

Diazinon®. *Ohio only*. Ohio has 24c special local needs for this product on potato for wireworm suppression.

Platinum® at 5-8 fl. oz. per acre. Apply to seed pieces.

Regent 4SC® at 0.184-0.220 fl. oz. per 1000 row feet, applied in-furrow at-planting.

Thimet 20G® before or at time of planting at the following rates:

Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).

Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

No effective treatment after planting. Treatment at planting may only provide 65% control. Apply as a band application on each side of row and beneath the soil surface, or in the seed furrow. 90-day PHI. *RUP*.

RR This is a reduced-risk pesticide. See page 34 for details.

Rhubarb

Varieties

McDonald, Sutton, Valentine (produces fewer seed stalks than McDonald) — all red-fleshed varieties.

Planting and Spacing

Crowns: Use only young, healthy crowns having preferably 2 or 3 buds. Rows 5 to 6 feet apart. Set crowns in rows 3 feet apart in shallow furrows so crowns will be 2 inches below surface.

Age for Harvesting

Harvest no longer than 4 weeks, beginning with the third season of growth. Harvest for about 8 to 10 weeks after the third season. Do not remove more than two-thirds of the developed stalks from any plant at one time.

Bolting (Seed Stalk Formation)

Infertile soil, extreme heat or cold, drought, or long days that expose plants to too much light may cause bolting. Old plants bolt more. Valentine is more sensitive than McDonald, Ruby, and most green-stalked varieties.

Fertilizing

Lime: To maintain a soil pH of 6.2 to 6.8.

Preplant: N: 50 pounds per acre. P_2O_5: 0 to 150 pounds per acre. K_2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Apply 25 additional pounds of P_2O_5 directly in furrows when setting the rootstalks (divided crowns).

Yearly: Only N needed. Broadcast 50 pounds N per acre before beds are worked in the spring. Topdress with 35 pounds N per acre after new growth resumes.

Disease Control

Ascochyta Leaf Spot

Fertilize in fall for growth in the spring. Remove older, yellowed leaves or leaves with lesions in the fall.

Crown Rot

Use disease-free plants. Plant only on well-drained soil.

Weed Control

Before spring growth, harrow bed thoroughly but carefully to avoid injuring the crowns. During the growing season, cultivate row-middles and hand hoe to keep the planting clean. Following the first light freeze in fall, mulch with 3-4 inches of straw around plants, but not on crowns. If additional mulch is needed in the spring, apply before hot, dry weather. Add more mulch during summer (if needed) to control weeds and retain moisture.

The herbicides listed below may also be used. Herbicides that control broadleaves must be applied while rhubarb is dormant or with shielded equipment between the row, as stated on the label. Herbicides that kill only emerged grasses may be applied over the top of rhubarb plants.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Dormant or Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2.5-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply in spring before buds begin to grow. Do not exceed 2 applications per season. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before plants emerge, or apply between rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Dormant or Shielded Applications Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Callisto 4L® at 6 fl. oz. per acre. Apply to dormant rhubarb. Use COC or NIS to improve control of emerged weeds. Has residual activity to control weeds that have not emerged. Do not exceed 6 fl. oz. per acre per year, or 1 application per year. 21-day PHI.

Dormant or Shielded Applications

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at 4 pts. per acre. Apply to dormant rhubarb before leaves emerge.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season.

Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

Poast 1.5E® at 1-1.5 per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 3 pts. per acre per season. 15-day PHI for Illinois, Indiana, and Minnesota. 30-day PHI for other states.

Insect Control

Aphids, Leafhoppers, Whiteflies

Recommended Products

RR **Actara**® at the following rates:

Aphids or leafhoppers: 1.5-3.0 oz. per acre.

Whiteflies: 3.0-5.5 oz. per acre.

Do not exceed 11 oz. per acre per season. 7-day PHI.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 7-day PHI.

RR **Fulfill**® at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 7-day PHI.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. *RUP*.

Platinum® at 5-11 fl. oz. per acre. 30-day PHI.

Pounce 25W® at 6.4-12.8 oz. per acre. Apply every 3-5 days (or as needed) in sufficient water to obtain full coverage of foliage. Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

Armyworms, Corn Earworms, Cutworms, Loopers

Recommended Products

Ambush 25W® at 6.4-12.8 fl. oz. per acre. 1-day PHI.

Baythroid® at 0.8-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 7-day PHI.

Coragen® at 3.5-5 fl. oz. per acre. 1-day PHI.

Entrust® at 1.25-2.5 oz. per acre. *Armyworms and loopers only*. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

RR **Intrepid 2F**® at 4-10 fl oz. per acre. *Armyworms and loopers only*. Do not exceed 64 fl. oz. per acre. 1-day PHI.

Larvin 3.2® at 16-30 fl. oz. per acre. *Not for cutworms*. Do not exceed 60 fl. oz. per acre per season. 14-day PHI. *RUP*.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. *RUP*.

Pounce 25W® at 6.4-12.8 oz. per acre. Also for European corn borers. Apply every 3-5 days or as needed in sufficient water to obtain full coverage of foliage. Do not exceed 8 lbs. per acre per season. 1-day PHI. *RUP*.

RR **Radiant SC**® at 5-10 fl. oz. per acre. *Not for cutworms*. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Common Stalk Borers, Rhubarb Curculios

There are no registered insecticides that will give adequate control.

Control by cultivating field and margins. Remove curly dock, the normal host of rhubarb curculios.

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Beet, Carrot, Parsnip, Radish, and Turnip

Varieties	
Beets	Ruby Queen, Crosby Greentop, Red Ace, Asgrow Wonder, Pacemaker III, Rosette
Carrots	Imperator: Premium, First Class, Avenger, Apache, Condor, Six-pack II, Navaho
	Dicer types: Red Cored Chantenay, Goliath, Royal Chantenay, Danvers 126, Gold King
	Slicer types: Heritage, Protege, PY 60 Improved
	Nantes: Atlanta, Bolero, Mokum
Parsnips	Harris' Model, Andover, Anoka
Radishes	Cherry Belle, Comet, Red Prince
Turnips	Purple Top White Globe, Seven Top (greens)

Spacing

Beets: Rows 18 to 24 inches apart. Seed 8 to 10 pounds per acre for bunching.

Carrots: Rows 16 to 30 inches apart. Plant 20 to 30 per foot for slicing/fresh market; 10 to 20 plants per foot for dicing.

Parsnips: Rows 18 to 24 inches apart. Seed 2 to 3 pounds per acre.

Radishes: Rows 15 inches apart. Plant 12 to 15 per foot of row. Seed 10 to 15 pounds per acre.

Turnips: Rows 14 to 18 inches apart. Plant 2 to 3 inches apart in row. Seed 1 to 2 pounds per acre.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.8; for beets, 6.5 to 7.0.

Preplant: N: 60 pounds per acre. P_2O_5: 20 to 160 pounds per acre. K_2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. If soil tests indicate that a high amount of K is necessary, plow down at least half the requirement. Beets also respond to boron when grown on sandy soils, light-colored silt and clay loams, and alkaline, dark-colored soils. Boron may be omitted on acid, dark-colored soils. Based on a boron soil test, include boron at 2 1/2 to 5 pounds per acre applied over the row at planting. Do not contact with seed. Boron is toxic to many vegetables, particularly beans, peas, and cucurbits. Thus, rotational plans may have to be adjusted. For carrots grown on muck soil with a soil pH greater than 6.0, add 6 pounds of manganese per acre.

Sidedress N

Beets, carrots, parsnips: for soils with more than 3 percent organic matter and following soybeans, alfalfa or a grass-legume hay crop, apply 30 pounds N per acre 4 to 6 weeks after planting. For soils with less than 3 percent organic matter and the above rotation, apply 45 pounds N per acre. Following corn, rye, oats, wheat, or a vegetable crop, apply 60 pounds N per acre.

Radish, turnip: none needed.

Disease Control

Aster Yellows (carrot and parsnip)

Use an insecticide to control leafhoppers that transmit the disease.

Excellent early season leafhopper control is essential. Control must occur before leafhoppers feed.

Cercospora Leaf Spot (Early blight), Alternaria Leaf Blight (Late Blight)

Practice a 3-4 year crop rotation.

Recommended Products

Cabrio EG® 8-12 oz. per acre. 0-day PHI.

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. *Carrots and parsnips only*. 0-day PHI for carrot. 10-day PHI for parsnip.

RR **Endura 70WG**® at 4.5 oz. acre. *Alternaria leaf blight on carrot only*. 0-day PHI.

Fontelis 1.67SC® at 16-30 fl. oz. per acre. 0-day PHI.

Monsoon®, **Toledo**®, or **Onset 3.6F**® at 3-7.2 fl. oz. per acre. *Cercospora on garden beet only*. 7-day PHI.

RR **Pristine 38WG**® at 8-10.5 oz. per acre. *Carrot only*. 0-day PHI.

RR **Quadris Flowable 2.08SC**® at 9-15.5 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 2.4 pts. per acre. *Carrot only*. 0-day PHI.

Rovral® at 1-2 pts. per acre for flowable (F) formulations. *Alternaria leaf blight on carrot only*. 0-day PHI.

Switch® at 11-14 oz. per acre. *Alternaria leaf blight only*. 7-day PHI.

Downy Mildew, White Rust

Practice a 3-year crop rotation. Plow crop residue as soon as possible after harvest. Avoid volunteer plants and cruciferous weeds.

Recommended Products

Cabrio EG® at 8-16 oz. per acre. *White rust only*. 0-day PHI.

RR **Quadris**® at 6-15.5 oz. per acre for root crops. *White rust only*. 0-day PHI.

Root Knot Nematode

Sample fields for plant parasitic nematodes before planting. Avoid fields with high numbers of root-knot nematodes

White Mold (carrot and parsnip)

Practice a 3-4 year crop rotation. Avoid including beans, cucurbits, celery, and late cabbage in the rotation.

Recommended Products

Fontelis 1.67SC® at 16-30 fl. oz. per acre. 0-day PHI

Weed Control

Cultivation and hand hoeing are usually important components of weed control in root crops. Design bed and row spacing to match equipment that will be used. Use of a stale seedbed is helpful.

Prepare the seedbed several weeks in advance of planting, allow weeds to emerge, and kill weeds without bringing new weed seeds to the surface. This can be done with an herbicide labeled for the crop, flaming, or very shallow cultivation. It may be possible to plant without killing the weeds, and then kill them until just before the crop emerges.

If the time between seedbed preparation and planting is short, weed emergence can be speeded up by putting a row cover over the soil. Weeds that emerge after seeding and before the crop can also be controlled with a labeled herbicide or flaming. For crops like carrots and parsnips that take a long time to emerge, controlling these weeds is especially useful, but it can also pay off for faster-emerging species like radishes or beets.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

RR **Glyphosate** products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qt. per acre. Broadcast before seeding, or apply between crop rows with wipers or hooded or shielded sprayers. Use lower rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Gramoxone Inteon 2L® at 2-4 pts. per acre. *Carrots and turnips only*. *Not for beets, horseradish, parsnips, or radishes.* Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before or after seeding but before crop emerges. *RUP*.

Preemergence Broadleaves and Grasses

Recommended Products

Dual Magnum® at the following rates:

Carrots in Indiana, Minnesota, and Ohio only. 0.67-1.3 pts. per acre on mineral soils, or 1.3-2 pts. per acre on muck soils (less than 20% organic matter). Apply postemergence after carrots have 3-5 true leaves. 64-day PHI.

Beet, radish, and turnip root in Indiana and Ohio only. 0.67-1 pt. per acre. Apply before planting with or without incorporation, or apply after seeding before crop emerges. Risk of crop injury is generally greater with preplant incorporated applications than with preplant or preemergence applications. Risk of crop injury is greater on coarse-textured soils with less than 1.5% organic matter. Do not exceed 1.3 pt. per acre per crop or 1 application per crop.

Lorox 50DF® at the following rates:

Carrots in Minnesota only: 1-2 lbs. per acre.

Parsnips: 1.5-3 lbs. per acre.

Do not use on sand, loamy sand, or soils with less than 1% organic matter. Apply after seeding before crop emerges. Plant seed at least 1/2 inch deep. Do not use on other root crops.

Nortron SC® at the following rates:

Preemergence: 60 fl. oz. per acre. Apply at (or soon after) seeding, and before weeds germinate.

Early postemergence: 5.25 fl. oz. per acre. Apply when beets have 2-4 true leaves.

Postemergence: 10.5 fl. oz. per acre. Apply when beets have 6-8 true leaves.

Beets only. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. Do not exceed 96 fl. oz. per acre per season.

Outlook® at 12-21 fl. oz. per acre. *Horseradish only*. Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may stunt horseradish. Will not control emerged weeds.

Prowl H2O® at 2 pts. per acre. *Carrots only*. Apply within 2 days after seeding and before crop and weeds emerge. Or apply at layby as a directed spray between rows. Do not allow spray to contact carrot plants. Will not control emerged weeds. Do not exceed 2 pts. per acre per season. 60-day PHI.

Trifluralin products at 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. *Carrots and radishes only*. Use lowest rate on coarse soils. Apply and incorporate before planting. Not effective on soils with high organic matter.

Preemergence Broadleaves

Recommended Products

Goal 2XL® at 2 pts. per acre. *Horseradish only*. Apply after planting prior to crop emergence.

Spartan 75DF®, at 1.5-5.3 oz. per acre, or **Spartan 4F**®, at 2.25-8.0 fl. oz. per acre, or **Spartan Charge**® at 2.9-10.2 fl. oz. per acre. *Horseradish only*. Spartan Charge® has postemergence contact activity. Broadcast in the spring before planting or after planting but at least 5 days before crop emergence; or band into row middles after crop emergence. Applications made in the spring shortly before planting may be incorporated, but do not incorporate at other times. Rainfall or irrigation is required to move herbicide into the soil when not incorporated. Do not broadcast if sprouts are close to soil surface, or over top of emerged crop. Do not use on sand soils with less than 1% organic matter. Do not exceed 5.3 oz. of Spartan 75DF® per 12-month period. Do not exceed 8 fl. oz. of Spartan 4F® per 12-month period. Do not exceed 10.2 fl. oz. of Spartan Charge® per 12-month period.

Pyramin 4.5SC® at 2.75-3.25 qts. per acre, or **Pyramin 65DF**® at 4.6-5.4 lbs. per acre. *Beets only*. Apply after seeding before crop emerges, or use high rate after beets have 2 expanded true leaves and before weeds have more than 2 leaves. Rainfall or irrigation necessary for effective control of nonemerged weeds. Do not apply if beets are stressed or injured. Do not use preemergence on muck soils; do not use at all on sands or sandy loam soils. Do not exceed 6.5 qts. of Pyramin 4.5SC® or 11.25 lbs. of Pyramin DF® per acre.

Preemergence Grasses

Recommended Products

Ro-Neet 6E® at 0.5-0.67 gals. per acre. *Beets only*. Apply before planting and incorporate immediately. Mineral soils only.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications Broadleaves and Grasses.

Nortron SC® See details above for Preemergence Broadleaves.

Lorox 50DF® at 1.5-3 lbs. per acre. *Carrots only*. *Not for postemergence use on other root crops.* Apply when crop is at least 3 inches tall. Will provide some residual control of nonemerged weeds. Do not apply if temperature is above 85°F. Do not exceed 4 lbs. per acre per season. Do not use on sand, loamy sand, or soils with less than 1% organic matter. 14-day PHI.

Postemergence Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Pyramin 4.5SC® See details above for Preemergence Broadleaves.

Sencor 4F® at 0.5 pt. per acre, or **Sencor 75DF®** at 0.33 lb. per acre. *Carrots only*. Broadcast after carrots have 5-6 true leaves and when weeds are less than 1 inch tall or across. Do not apply within 3 days of cool, cloudy weather, or other pesticide application, or when temperature is above 85°F. Do not exceed 1 application per season if carrots are rotated with onions; otherwise do not exceed 1 pt. of Sencor 4F® or 0.66 lb. of Sencor 75DF® per acre. 60-day PHI.

Spin-Aid 1.3E® at 3-6 pts. per acre in 11-22 gals. of water. *Beets only*. Apply to beets with 4 true leaves to avoid injury. Do not apply if beets are stressed. Does not control pigweed. 60-day PHI.

Stinger 3L® at 8 fl. oz. per acre. *Beets and turnips only*. Controls primarily composites and nightshade. Do not exceed 1 application per acre. 30-day PHI for beets and turnip roots.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season.

Spray on actively growing grass. Wait at least 14 days between applications. 15-day PHI for radishes. 30-day PHI for root crops. 14-day PHI for turnip greens.

Fusilade DX® at 10-12 fl. oz. per acre. *Carrots only*. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Spray on actively growing grass. 45-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre. *Beets, carrots, horseradish, parsnips, radishes, and turnips only*. *Not for beet greens*. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 2.5 pts. per acre per season for parsnips, radishes, and turnips; or 5 pts. per acre per season for beets, carrots, and horseradish. 14-day PHI for parsnips, radishes, and turnips. 30-day PHI for carrots. 60-day PHI for beets and horseradish.

A partially harvested turnip field.

Herbicides for Root Crops: Beet, Carrot, Horseradish, Radish and Turnip[1]

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop[2]				Incorporated	Timing Relative to Weeds		Weed Groups Controlled			Crops[3]					
		Before seeding/planting	After seeding / planting before emergence	Post emergence -between rows only	Postemergence		Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Beet	Carrots	Horseradish	Parsnip	Radish	Turnip roots
Aim EC* (12h)	carfentrazone			X				X		X	X	X	X	X	X	X	X
Dual Magnum® (24/variable)	s-metolachlor	X	X				X		X	X		X	X			X	X
Goal* (12h/-)	oxyfluorfen		X				X			X	X			X			
Gramoxone Inteon 2L* (12h to 24h)	paraquat	X	X					X	X	X	X		X			X	
Lorox 50DF* (24h/14d)	linuron		X		X		X		X				X		X		
Nortron SC* (12h/-)	ethofumesate	X	X		X		X	X	X	X		X					
Outlook* (12h/5-)	dimethenamid-P				X		X		X	X				X			
Poast* (12h/14d to 60d)	sethoxydim				X			X	X			X	X	X	X	X	X
Prowl* (12h/60d)	pendimethalin		X	X			X		X	X			X				
Pyramin* (12h/-)	pyrazon		X		X		X	X		X	X	X					
Ro-Neet* (12h/-)	cycloate	X				Yes	X		X			X					
Roundup*, others (12h/14d)	glyphosate	X		X				X	X	X	X	X	X	X	X	X	X
Select Max*, others (12h/15d to 30 d)	clethodim				X			X	X			X	X	X	X	X	X
Sencor* (12h/60d)	metribuzin				X			X		X	X		X				
Spartan* (12h/-)	sulfentrazone	X	X	X			X			X	X			X			
Spartan Charge* (12h/-)	sulfentrazone + carfentrazone	X	X	X			X	X		X	X			X			
Spin-Aid* (12h/60d)	phenmedipham				X			X		X	X	X					
Stinger* (12h/30d)	clopyralid				X			X		X	X	X					X
Treflan*, others (12h/-)	trifluralin	X				Yes	X		X	X			X			X	

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.
[2]X=permitted for at least one crop.
[3]X=may be used for that crop; check label for application methods permitted.

Insect Control for Beets

Aphids

Recommended Products

(RR) **Actara**® at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

Malathion 5EC® at 1.5-2 pts. per acre. 7-day PHI.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

(RR) **Platinum**® at 5-12 fl. oz. per acre. Apply at planting.

Variegated Cutworms

Recommended Products

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 21-day PHI.

Lannate SP® at 0.5 lb. per acre. Do not exceed 8 applications or 4 lbs. per acre per crop. 0-day PHI for roots. 10-day PHI for tops. *RUP*.

Mustang MAX® at 1.28-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

Insect Control for Carrots

Aphids

Recommended Products

(RR) **Actara**® at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

Endosulfan 3EC® at 0.66-1.33 qts. per acre. Do not exceed 1 application per year. 7-day PHI.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

(RR) **Platinum**® at 5-12 fl. oz. per acre. Apply at planting.

Cutworms

Cutworm Threshold

25% of plants infested

Recommended Products

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 7-day PHI. *RUP*.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 21-day PHI.

Diazinon 50W® at 4-8 lbs. per acre, or **Diazinon AG500**® at 2-4 qts. per acre. Broadcast just before planting and immediately incorporate into the soil. Do not exceed 5 applications per season. 14-day PHI. *RUP*.

Lannate SP® at 0.25-0.5 lb. per acre. Do not exceed 7 lbs. per acre per season. 1-day PHI. *RUP*.

Mustang Max® at 1.28-4 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 1-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

Leafhoppers

Plant resistant varieties. Use varieties resistant to aster yellows.

Leafhopper Threshold

For susceptible varieties: 20 leafhoppers per 100 sweeps

Recommended Products

(RR) **Actara**® at 1.5-3.0 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 7-day PHI. *RUP*.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. *RUP*.

Lannate SP® at 0.5-1 lb. per acre. Do not exceed 7 lbs. per acre per season. 1-day PHI. *RUP*.

(RR) **Platinum**® at 5-12 fl. oz. per acre. Apply at planting.

Sevin XLR PLUS® at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

(RR) This is a reduced-risk pesticide. See page 34 for details.

Insect Control for Radishes

Aphids, Flea Beetles

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 4 oz. per acre per season. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 a.i. or 1 application per season. 21-day PHI.

Asana XL® at 5.8-9.6 oz. per acre. *Flea beetles only.* Do not exceed 19.2 fl. oz. per acre per season. 7-day PHI. *RUP*.

Baythroid® at 1.6-2.8 fl. oz. per acre. *Flea beetles only*. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 21-day PHI.

Malathion 5EC® at 1.5 pts. per acre. 7-day PHI.

M-Pede® at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

RR **Platinum**® at 5-6.5 fl. oz. per acre. Apply at planting.

Sevin XLR PLUS® at 0.5-1 qt. per acre. *Flea beetles only*. Do not exceed 6 qts. per acre per season. 7-day PHI.

Cutworms

Recommended Products

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 21-day PHI.

Diazinon 50W® at 4-8 lbs. per acre, or **Diazinon AG500**® at 2-4 qts. per acre. Broadcast just before planting and immediately incorporate into the soil. 14-day PHI. *RUP*.

Mustang Max® at 1.28-4 fl. oz. per acre. 1-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

Root Maggots

Recommended Products

Lorsban 4E® at 1 fl. oz. per 1,000 linear ft. of row, or **Lorsban 75WG**® at 0.67 oz. per 1,000 linear ft. of row. Apply as a furrow application at planting. Apply as a water-based drench and use a minimum of 40 gals. of water. Do not exceed 1 application per season.

Insect Control for Turnips

Aphids, Flea Beetles

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

Ambush 25W® at 3.2-6.4 fl. oz. per acre. *Aphids in Illinois and Indiana only*. Do not exceed 8 applications per acre per season. 1-day PHI. *RUP*.

Asana XL® at 5.8-9.6 oz. per acre. *Flea beetles only*. Do not exceed 76.8 fl. oz. per acre. 7-day PHI. *RUP*.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre, or **Brigade WSB**® at 5.3-16.0 oz. per acre. 21-day PHI.

Malathion 5EC® at 1-2 pts. per acre. 7-day PHI.

BP **Neemix**® according to label directions. 0-day PHI.

RR **Platinum**® at 5-12 fl. oz. per acre. 30-day PHI.

Root Maggots

Recommended Products

Lorsban 4E® at 1.6-2.75 fl. oz. per 1,000 linear ft. of row, or **Lorsban 75WG**® at 1.1-1.8 oz. per 1,000 linear ft. of row.Apply as a furrow application at planting. Apply as a water-based drench and use a minimum of 40 gals. of water. Do not exceed 1 application per acre per season.

RR This is a reduced-risk pesticide. See page 34 for details.

BP This is a biopesticide. See page 34 for details.

Sweet Corn

Sweet Corn Types

Sweet corn is usually described by color (yellow, bicolor, or white) and by the major genes that make it sweet. The original sweet corn (called standard, sugary, or su) contains the su1 genetic variant that makes it sweet instead of starchy like field corn. Sugary sweet corn is grown today primarily for processing and specialized markets.

A second type of sweet corn is called sugar-enhanced, sugary enhancer, EH, or se corn because it contains the se1 genetic variant that increases sugar content and makes the kernels more tender. Heterozygous se corn has one copy of the se1 mutation, and homozygous se corn has two copies of the se1 mutation, increasing its effect. Sugar-enhanced sweet corn is grown primarily for direct retail sales and local wholesale markets.

A third type of sweet corn, called supersweet, ultrasweet, extra sweet, or shrunken-2 contains the sh2 genetic variation. This type typically has a higher sugar content than sugary corn, and the sugar content does not decline rapidly after picking, so it remains sweet for several days after harvest. Kernels typically are not as tender as se corn. Supersweet types are grown for retail sales, local fresh markets, and wholesale shipping markets.

Some of the newest sweet corn varieties combine the sh2 with su and/or se genetics in new ways. Many of these new varieties have performed well in Midwestern trials and are gaining popularity. The new types are often identified by trademarked brand names and described as having enhanced eating quality. Consult with seed company representatives and sweet corn trial researchers to identify varieties suitable for your needs.

Isolation Requirements

Sweet corn flavor is affected by pollen source. All sweet corn types should be isolated from field corn pollen by 250 feet or by a 14-day difference in tasselling dates. Supersweet (sh2) varieties must be similarly isolated from sugary and sugar-enhanced types. If not isolated, kernels of both varieties will be starchy instead of sweet.

It is not essential to isolate sugar-enhanced (se) sweet corn from sugary (su) sweet corn: cross-pollination will not result in starchy kernels. However, isolation permits the full expression of sugar-enhanced traits. Likewise, to get the full benefits of new genetics, isolation is usually recommended for the new combinations of sh2 and se or su. If complete isolation is not possible, plants should at least be isolated from pollen that will increase the proportion of starchy kernels. Refer to the table below for isolation requirements or check with your seed supplier.

To maintain color purity, isolate white corn from yellow or bi-color corn. Pollen from yellow or bi-color corn will cause some yellow kernels in white varieties. Pollen from yellow corn will lead to extra yellow kernels in bi-color varieties. Pollen from white corn will not affect yellow or bi-color varieties.

Sweet Corn Isolation Requirements[1]

Corn Type or Brand	Isolate from these Types or Brands
Standard (su)	Shrunken-2, Xtra Tender, Gourmet Sweet
Sugar-enhanced (se)	Shrunken-2, Xtra Tender, Gourmet Sweet
TripleSweet, Synergistic	Shrunken-2, Xtra Tender, Gourmet Sweet
Shrunken-2 (sh2)	Standard, Sugar-enhanced, TripleSweet, Synergistic
Xtra Tender, Gourmet Sweet	Standard, Sugar-enhanced, TripleSweet, Synergistic

[1]Isolate all types from field corn.

Spacing

Rows 30 to 40 inches apart. Plant early varieties 8 to 10 inches apart in the row, late varieties 9 to 12 inches apart in the row.

Seed 10 to 15 pounds per acre.

Fertilizing

Lime: To maintain a soil pH of 6.0 to 6.5.

Preplant: N: 60 pounds per acre. P_2O_5: 0 to 100 pounds per acre. K_2O: 0 to 150 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For early season varieties, apply a starter fertilizer at planting. Do not exceed 80 to 100 pounds of N + K_2O per acre in the fertilizer band (2 inches to the side of the row and 2 inches below the seed). A good starter fertilizer would be 200 pounds per acre of 6-24-24, or 10 gallons of 10-34-0 or similar analysis. On sandy soils, broadcast 30 pounds or band 15 pounds of sulfur per acre.

Sidedress N: For loam or finer textured soils, apply 30 to 40 pounds N per acre when plants are 4 to 5 inches tall, and before they are 10 inches tall. If the soil organic matter content exceeds 3 percent and/or sweet corn follows a legume, this sidedressed N application could be skipped unless there has been excessive rainfall. For irrigated sandy loam soils along river areas, the N preplant application should be replaced with two sidedressings of approximately 40 pounds N per acre each: one when 4 to 5 inches tall (4th to 5th leaf), and the other at 10 inches tall (10th to 12th leaf).

Disease Control

Anthracnose

Recommended Products

Headline® at 6-12 fl. oz. per acre. 7-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 7-day PHI.

RR **Quadris Flowable**® at 6.2-15.5 fl. oz. per acre. 7-day PHI.

Quilt® at 10.5-14 fl. oz. per acre. 14-day PHI.

Quilt Xcel® at 10.5-14 fl. oz. per acre. 14-day PHI.

"Helminthosporium" Leaf Blight, Southern Corn Leaf Blight, Northern Corn Leaf Blight, Northern Corn Leaf Spot

Plant resistant varieties. For an up-to-date list of sweet corn hybrid reactions to prevalent diseases, visit the University of Illinois' Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu. Or refer to the Purdue Extension bulletin, *Midwest Vegetable Trial Report*, available from The Education Store, www.the-education-store.com.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. Note that rates vary for different diseases. 14-day PHI.

Headline® at 6-12 fl. oz. per acre. 7-day PHI.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled at various rates. 7-day PHI.

Monsoon 3.6F®, **Toledo 3.6F**®, or **Onset 3.6F**® at 4-6 fl. oz. per acre. 7-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 7-day PHI.

Propimax EC® at 2-4 fl. oz. per acre. 14-day PHI.

RR **Quadris Flowable**® at 6.2-15.5 fl. oz. per acre. 7-day PHI.

Quilt® at 7-14 fl. oz. per acre. 14-day PHI.

Quilt Xcel® at 10.5-14 fl. oz. per acre. 14-day PHI.

Tilt® at 2-4 fl. oz. per acre. 14-day PHI.

Rust

Plant rust-resistant hybrids — see the University of Illinois' Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu, or the Purdue Extension bulletin *Midwest Vegetable Trial Report*, available from The Education Store at www.the-education-store.com.

A new race of the rust fungus capable over overcoming resistance in many sweet corn hybrids has been observed in the Midwest for the past several years. Sweet corn hybrid resistance to rust will depend on the hybrid's particular Rp-resistant gene, its general (background) resistance, and the race(s) of the rust fungus prevalent in the planting.

Recommended Products

Bravo®, **Echo**®, and **Equus**® are labeled for use at various rates. 14-day PHI.

Headline® at 6-12 fl. oz. per acre. 7-day PHI.

Dithane®, **Manzate**®, and **Penncozeb**® are labeled for use at various rates. 7-day PHI.

Monsoon 3.6F®, **Toledo 3.6F**®, or **Onset 3.6F**® at 4-6 fl. oz. per acre. 7-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 7-day PHI.

Propimax EC® at 4 fl. oz. per acre. 14-day PHI.

RR **Quadris Flowable**® at 6.2-9.2 fl. oz. per acre. 7-day PHI.

Quilt® at 10.5-14 fl. oz. per acre. 14-day PHI.

Quilt Xcel® at 10.5-14 fl. oz. per acre. 14-day PHI.

Tilt® at 4 fl. oz. per acre.14-day PHI.

Smut

Some hybrids tend to have fewer smut infections. Use past experience to choose successful hybrids. Avoid mechanical damage to corn plants. Try to avoid plant stresses that affect pollen production and silk emergence.

Stewart's Wilt

Plant wilt-resistant hybrids — see the University of Illinois' Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu, or the Purdue Extension bulletin *Midwest Vegetable Trial Report*, available from The Education Store at www.the-education-store.com.

Use an insecticide or seed treatment to control flea beetles. Insecticide treatments are more likely to be necessary in seasons following a mild winter.

Virus Diseases (maize dwarf mosaic, chlorotic dwarf, wheat streak mosaic)

Plant resistant or tolerant varieties — see the University of Illinois' Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu, or the Purdue Extension bulletin *Midwest Vegetable Trial Report*, available from The Education Store at www.the-education-store.com.

Control Johnsongrass and volunteer wheat.

Weed Control

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Atrazine Restrictions

Many herbicides labeled for corn contain atrazine. Observe the following restrictions on atrazine from all sources:

1. On highly erodible soils with low residue, do not apply more than 1.6 lbs. a.i. atrazine per acre before corn emerges.
2. On all soils, do not apply more than 2 lbs. a.i. atrazine per acre in one application.
3. On all soils, do not apply more than 2.5 lbs. a.i. atrazine per acre per year.
4. Check www.atrazine-watershed.info or call (800) 365-3014 for additional local restrictions on the use of any material containing atrazine.
5. Water-quality setbacks. See labels for detailed information. Do not apply within 66 feet of the points where field surface water runoff enters perennial or intermittent streams and rivers, or within 200 feet around natural or impounded lakes and reservoirs. On highly erodible slopes, the 66 foot buffer must be seeded to a crop or grasses to provide cover. On tile-outletted terraced fields, one of the following must be done: (1) do not apply within 66 feet of standpipes, (2) no setback buffer around tile inlets, but immediately incorporate it to a depth of 2-3 inches in the entire field, or (3) no setback buffer around tile inlets, but maintain high crop surface residue such as in no-till systems.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

Gramoxone Inteon 2L® at 2-4 pts. per acre. Use 1 qt. COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before or after seeding but before crop emerges. Or use 1-2 pts. of Gramoxone Inteon 2L® and apply between rows using hooded or shielded sprayers, or wait until corn is more than 10 inches tall and apply between rows using directed spray that reaches no higher than 3 inches up the corn stalk. Corn plants contacted by spray may be injured or killed. *RUP*.

Glyphosate products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before or after seeding but before crop emerges; or after corn is 12 inches tall, apply up to 0.75 lb. ae between crop rows with hooded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 7-day PHI.

Preemergence Broadleaves and Grasses

Recommended Products

Acetochlor products including:

Breakfree 6.4EC® at 1.5-3.75 pts. per acre.

Degree 3.8ME® at 2.75-5.5 qts. per acre.

Harness 7EC® at 1.5-3.0 pts. per acre.

Surpass 6.4EC® at 1.5-3.75 pts.per acre.

TopNotch® at 2-3 qts. per acre.

Breakfree ATZ® (acetochlor + atrazine 3.0 + 2.25 ai) at 2.2-3.4 qts. per acre.

Breakfree ATZ Lite® (acetochlor+atrazine 4.0 + 1.5 ai) at 1.6-3.0 qts. per acre.

Degree Xtra® (acetochlor + atrazine 2.7 + 1.34 ai) at 2.9-3.7 qts. per acre.

FulTime® (acetochlor + atrazine 2.4 + 1.6 ai) at 2.5-5.0 qts. per acre.

Harness Xtra 5.6L® (acetochlor + atrazine 3.1 + 2.5 ai) at 1.4-3 qts. per acre.

Harness Xtra® (acetochlor + atrazine 4.3 +1.7 ai) at 1.8-3.3 qts. per acre.

Keystone® (acetochlor + atrazine 3.0 + 2.25 ai) at 2.2-3.4 qts. per acre, or **Keystone LA**® (acetochlor + atrazine 4.0 + 1.5 ai) at 1.6-3.0 qts. per acre.

Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before sweet corn emerges. May be mixed with atrazine or simazine. See label for details. Do not apply to light textured soils specified in the label where ground water is at 30 ft. or less. *RUP*.

Alachlor products containing 4 lbs. a.i. per gal. at 2-3.25 qts. per acre. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before corn emerges. May be mixed with atrazine, see label for details. *RUP*.

Atrazine products at 1-2 lbs. active ingredient (a.i.) per acre. Use 4L formulations at 1-2 qts. per acre, or 90W formulations at 1.1-2.2 lbs. per acre. To control small, emerged broadleaves, include 1 qt. of COC per acre. Apply before planting and incorporate, after planting before corn emerges, or after emergence before corn is 12 inches tall. Potential for carryover in soil and injury to following crops. Consult label for details. Do not exceed 1.6 lbs. a.i. per acre before corn emerges on highly erodable soils with low residue; do not exceed 2.5 lbs. a.i. total per acre per year. *RUP*.

Anthem® for processing and fresh market sweet corn at the following rates:

Soils with <3% organic matter: 7-11 fl. oz. per acre depending on soil texture (check label).

Soils with >3% organic matter: 7-13 fl. oz. per acre depending on soil texture (check label).

For control of many broadleaf and grass weeds. Do not make more than 1 application to spring corn. 18-month replant restriction for all crops except corn. 40-day PHI.

Anthem ATZ® for processing and fresh market sweet corn at the following rates:

Soils with <3% organic matter: 1.75-3 pts. per acre depending on soil texture (check label).

Soils with >3% organic matter: 1.75-4 pts. per acre depending on soil texture (check label).

For control of many broadleaf and grass weeds. Do not make more than 1 application to spring corn. 18-month replant restriction for all crops except corn. 45-day PHI.

Define 60DF® at 12-21 oz. per acre, or **Define SC**® at 15-25 fl. oz. per acre. Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before sweet corn emerges. May be tank mixed with atrazine or simazine. See labels for details.

Dimethenamid-P (1.7 lbs. a.i. per gallon) **plus atrazine** (3.3 lbs. a.i. per gallon) products at 2.5-4.6 pts. per acre — including the following: Guardsman Max®, Commit ATZ®, and Establish ATZ®. Or Dimethenamid-P (2.25 lbs. a.i. per gallon) plus atrazine (2.75 lbs. a.i. per gallon) products at 2.0 to 3.5 pts. per acre — including the following: G-Max Lite®, Commit ATZ Lite®, and Establish ATZ Lite®. Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Rates may be reduced if corn will be cultivated or full-season control is not needed. If multiple applications are made, do not exceed maximum rate per acre per year. 50-day PHI. *RUP*.

Lexar® or **Lexar EZ**® at 3 or 3.5 qts. per acre; or **Lumax**® at 2.5 or 3 qts. per acre; or **Lumax EZ**® at 2.7 or 3.25 qts. per acre. Use low rate on soils with organic matter less than 3%. Apply up to 14 days before planting or apply after planting before corn emerges. To control emerged broadleaves include COC at 1% v/v or NIS at 0.25% v/v. Note organophosphate insecticide precautions. Lexar® and LexarEZ® contain 1.74 lbs. s-metolachlor, 0.22 lb. mesotrione and 1.74 lb. atrazine per gallon. Lumax® contains 2.68 lbs. s-metolachlor, 0.268 lb. mesotrione and 1 lb. atrazine per gallon. LumaxEZ® contains 2.49 lbs. s-metolachlor, 0.249 lb. mesotrione, and 0.94 lb. atrazine per gallon. Do not use these products if topramezone (such as Impact®) or other products containing mesotrione (such as Callisto®) have been or will be applied the same growing season. Do not exceed 3.5 qts. of Lexar® or LexarEZ® per acre per year. Do not exceed 3 qts. of Lumax® per acre per year. Do not exceed 3.25 qts. of LumaxEZ® per acre per year. 60-day PHI. *RUP*.

Outlook® at 10-21 fl. oz. per acre. Use lower rate on coarse soils low in organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Apply preemergence for best activity. Do not exceed 21 fl. oz. of Outlook® per acre per year. 50-day PHI.

Prowl H2O® at 2- 4 pts. per acre. Use low rates on coarse soils with low organic matter. Apply after planting before corn emerges, or after emergence until corn is 20-24 inches tall or shows 8 leaf collars. Plant corn at least 1.5 inches deep and make sure seed is well covered. Use drop nozzles and directed spray for post applications, if necessary, to get spray to soil. Do not apply both pre- and postemergence.

s-metolachlor products containing 7.6 lbs. a.i. per gal. at 1-2 pts. per acre — including the following: Brawl®, Brawl II®, Dual Magnum®, Dual II Magnum®, Charger Basic®, and Cinch®. Use lower rate on coarse soils. Apply before planting and incorporate, or apply after planting before corn emerges. May also be applied as a directed spray between rows when corn is 5-40 inches tall. Incorporate to control nutsedge. May be mixed with atrazine, see label for details. Do not exceed 3.9 pts. per acre per year.

s-metolachlor (2.4 lbs. per gallon) **plus atrazine** (3.1 lbs. per gallon) products at 1.3-2.6 qts. per acre — including the following: Bicep II Magnum®, Cinch ATZ®, and Charger Max ATZ®. Or s-metolachlor (3.33 lbs. per gallon) plus atrazine (2.67 lbs. per gallon) at 0.9-2.2 qts. per acre — including the following: Bicep Lite II Magnum®, Cinch ATZ Lite®, Charger Max ATZ Lite® Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 5 inches tall. May also be applied as a directed spray between rows when corn is 5-12 inches tall. Do not

exceed 3.2 qts. per acre per year of products with 3.1 lbs. atrazine per gallon. Do not exceed 3.75 qts. per acre per year of products with 2.67 lbs. atrazine per gallon. 30-day PHI. *RUP*.

Zidua® at 1.0-4 oz. per acre. Apply before or after planting and before crop emergence, or at spiking up to V4 (4 leaf collars visible). May be incorporated. Will not control emerged weeds. May be tank mixed or applied sequentially with many other products. Seed at least 1 inch deep. Do not exceed 2.75 oz. per acre per season on coarse soils. Do not exceed 5 oz. per acre per season on other soils. 37-day PHI.

Preemergence Broadleaves

Recommended Products

RR **Callisto**® at 6-7.7 fl. oz. per acre. Processing and fresh market varieties. Some varieties may be severely injured. Adding atrazine at 0.75 lb a.i. per acre will improve weed control. Peas are very sensitive to Callisto®, observe rotation and drift management recommendations. Note organophosphate insecticide precautions. Not recommended if products containing mesotrione (e.g., Lexar® or Lumax®) or topramezone (e.g., Impact®) have been (or will be) applied to crop. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto®) from all sources. 45-day PHI.

Postemergence Grasses and Broadleaves

Recommended Products

Accent Q® at 0.45-0.90 oz. per acre. Use 1 qt. of COC or 8 fl. oz. of NIS per 25 gals. of spray solution. Apply broadcast or with drop nozzles on corn up to 12 inches tall or up through 5 leaf collars. For corn 12-18 inches tall use drop nozzles. Do not apply to corn more than 18 inches tall or showing 6 leaf collars or more. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Not recommended for use on corn previously treated with Counter®, Lorsban®, or Thimet® insecticides.

Impact 75DG® at 0.5-0.75 oz. per acre. Apply with 1.0-1.5% v/v COC or MSO, with UAN at 1.25-2.5 % v/v, or with AMS at 8.5-17 lbs. per acre. Tank mixing with atrazine will improve efficacy and spectrum of weed species controlled. Not recommended to be tank mixed with, or applied sequentially to products that contain mesotrione (Callisto® products). 45-day PHI.

Laudis 3.5SC® at 3 oz. per acre. Apply with 1% v/v MSO plus 8.5 lbs. of AMS per 100 gals. of spray solution. COC is less efficacious than MSO but can be used instead of MSO when broadleaves are the main target and conditions for control are excellent. Tank mixing with atrazine will improve efficacy and spectrum of weed species controlled.

Option 35WDG® at 1.5-1.75 oz. per acre. Apply with MSO at 1.5 pts. per acre with either AMS at 1.5-3 lbs. per acre, or UAN at 1.5-2 qts. per acre. Not recommended or precautions apply for use on corn previously treated with Counter®, Lorsban®, or Thimet® insecticides (see labels). Possible hybrid sensitivity. 45-day PHI.

Roundup PowerMax® or **Roundup WeatherMax**® at 0.66-3.3 qts. per acre before corn emerges, or at 16-22 fl. oz. per acre after corn has emerged. *Roundup Ready® sweet corn only*. Other corn will be killed. May be tank mixed with several preemergence or postemergnence herbicides labeled for corn. Use of other herbicides with residual activity is recommended if Roundup® is used. Postemergence applications may be made over the top of corn through the 8 leaf-collar stage (V8) or until corn is 30 inches tall. Drop nozzles are recommended if corn is more than 24 inches tall, and must be used if corn is more than 30 inches tall to prevent spraying into whorls. Do not apply to corn more than 30 inches tall if it has reached the reproductive stage. Do not exceed 3.3 qts. per acre prior to crop emergence. Do not exceed 44 fl. oz. per acre in a single application in the crop. Do not exceed 4.1 qts. per acre per growing season from emergence through crop height of 48 inches. Do not exceed 5.3 qts. per acre for all applications. 30-day PHI if corn is harvested for forage or grain.

Postemergence Broadleaves

Recommended Products

2, 4-D formulations at the following rates:

Amine formulations at 0.25-0.75 lb. a.i. per acre.

4L formulations at 0.5-1.5 pts. per acre.

Use lower rates on annual weeds and higher rates on perennial weeds in the bud stage. Use drop nozzles if corn is more than 8 inches tall. Do not apply to open whorls or within 2 weeks of tasseling through harvest. Avoid drift onto other vegetable crops. Can cause severe injury to some varieties.

Aim EC® at 0.5 fl. oz. per acre. Use 8 fl. oz. of NIS per 25 gals. of spray solution. Apply to weeds up to 4 inches tall and apply up to the 14 leaf-collar stage of sweet corn. To reduce injury, the label requires using drop nozzles or other directed sprayers to minimize application to the whorl. Do not exceed 2 fl. oz. of Aim EC® per acre per season.

Anthem® at 5-12 fl. oz. per acre depending on soil texture (check label). *For processing sweet corn only when used postemergence.* For control of several broadleaf weeds. Most broadleaf weeds need to be less than 2 inches tall. Add an adjuvant such as a NIS or a silicone-based surfactant at 8 fl. oz. per 25 gals. of spray solution, or add COC or MSO at 1-2 pts. per acre for best activity. In addition to an adjuvant, you can add UAN at 1-2 qts.

RR This is a reduced-risk pesticide. See page 34 for details.

per acre or spray grade AMS at recommended-use rates to the spray solution. Before applying to corn, confirm that your line has Anthem® selectivity with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop response can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. Do not make more than 1 application to spring corn. 18-month replant restriction for all crops except corn. 40-day PHI.

Anthem ATZ® at 1.5-3 pts. per acre depending on soil texture (check label). *For processing sweet corn only when used postemergence.* For control of several broadleaf weeds. Apply from crop emergence through V4 growth stage. Most broadleaf weeds need to be less than 4 inches tall. Add an adjuvant such as a NIS or a silicone-based surfactant at 8 fl. oz. per 25 gals. of spray solution, or add COC or MSO at 1-2 pts. per acre for best activity. In addition to an adjuvant, you can add UAN at 1-2 qts. per acre or spray grade AMS at recommended-use rates to the spray solution. Before applying to corn, confirm that your line has Anthem® selectivity with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop response can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. Do not make more than 1 application to spring corn. 18-month replant restriction for all crops except corn. 45-day PHI.

Bentazon products at 0.75-1 lb. a.i. per acre. Use 4L formulations at 0.75-1 qt. per acre. Use 1 qt. of COC per acre. Apply to small weeds. Also controls nutsedge. Do not apply to corn that is stressed because injury may result. Combine with atrazine to broaden weed control spectrum.

Cadet® at 0.6-0.9 fl. oz. per acre. *For processing sweet corn only.* Apply from 2 collars to tasseling. Controls velvetleaf and several other broadleaves. Add COC or NIS. Do not exceed 1.25 fl. oz. per acre per year. 40-day PHI.

Callisto® at 3 oz. per acre. Processing and fresh market varieties. Some varieties may be severely injured. Include NIS at 0.25% v/v or COC at 1.0% v/v. Adding NIS is preferable to COC to reduce crop injury. COC will improve weed control under dry conditions. Do not add UAN or AMS. Adding atrazine at 0.25-0.5 lb. of a.i. per acre will improve weed control. Peas are very sensitive to Callisto®; observe rotation and drift management recommendations. Note organophosphate insecticide precautions. Not recommended if products containing mesotrione (e.g., Lexar® or Lumax®) or topramezone (e.g., Impact®) have been (or will be) applied to crop. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto®) from all sources. 45-day PHI.

Callisto Xtra® at 20-24 fl. oz. per acre. Apply with 8 fl. oz. of NIS or 1 qt. of COC per 25 gals. spray solution. Apply after corn emerges and before corn is 12 inches tall. Also controls large crabgrass. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Do not use on corn previously treated with Lorsban® or Counter® insecticides, or within 7 days of treatment with any organophosphate or carbamate insecticide. Contains 0.5 lb. of mesotrione and 3.2 lbs. of atrazine per gal. Do not exceed 0.24 lb. mesotrione or 2.5 lbs. atrazine per acre per year from all sources. Maximum one application per year. 45-day PHI.

Halosulfuron products, including **Sandea**® or **Permit**®, at 2/3-1 oz. per acre. Apply over the top or with drop nozzles from the spike through layby stages. Has some soil residual activity. A second application of 2/3 oz. per acre may be made only with drop nozzles aimed to avoid application into whorls. Do not exceed 2 applications per 12-month period. 30-day PHI.

Starane 1.5L® at 0.66 pt. per acre, or **Starane Ultra 2.8L**® at 0.4 pt., per acre. Apply broadcast or as a directed spray to corn that has up to 4 fully exposed leaf collars. Use directed spray when corn is beyond the 4-leaf collar stage. For volunteer potato, can apply preplant to emerged potato followed by a second application postemergence to emerged potato. 31-day PHI.

Stinger 3L® at 0.33-0.66 pt. per acre. Spray on actively growing weeds before corn is 18 inches tall. Controls primarily composites and nightshade. Wait 21 days between applications. Do not exceed 0.66 pt. per crop per year. 30-day PHI.

Topramezone products at the following rates:

Impact® at 0.5-0.75 fl. oz. per acre. Do not exceed 0.75 fl. oz. per acre.

Armezon® at 0.5 to 1.0 fl. oz. per acre. Do not exceed 1.0 fl. oz. per season.

Add MSO or COC and urea ammonium nitrate (UAN), ammonium phosphate (10-34-0), or ammonium sulfate. See specific label for additive rates as they vary slightly between products. Not recommended if products containing mesotrione have been or will be applied to crop. 45-day PHI.

Postemergence Grasses

Recommended Products

Poast® at 0.75-1.5 pts. per acre. *Poast Protected® varieties only* — will kill other crops. Use 1 pt. Dash®, 1.5 pts. MSO, or 2 pts. COC per acre. UAN or AMS are optional, see label. For use only on Poast®-tolerant sweet corn varieties. Such varieties are clearly labeled. May repeat applications up to 3.0 pts. Poast® total per acre per season. 30-day PHI.

Herbicides for Sweet Corn[1]

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop[2]					Timing Relative to Weeds		Weed Groups Controlled			Comments
		Before planting	After planting before crop emergence	Spiking to layby	Postemergence up to defined crop stage	Postemergence, directed/shielded	Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	
2,4-D amine (48h/-)	2,4-D				X	X		X		X	X	
acetochlor (12h/-)	acetochlor	X	X				X		X	X	X	Premixes with atrazine are available
Aim* (12h/-)	carfentrazone				X	X		X		X	X	
alachlor products (12h/-)	alachlor	X	X				X		X	X	X	
atrazine (12h/-)	atrazine	X	X		X		X	X		X	X	
bentazon products, (12h/30d)	bentazon							X		X	X	Effective against nutsedge
Cadet* (12h/40d)	fluthiacet-methyl				X			X		X	X	Processing sweet corn only
Callisto* (12h/45d)	mesotrione	X	X		X		X	X		X	X	
Callisto Xtra* (12h/45d)	mesotrione + atrazine				X			X		X	X	Controls large crabgrass
Define* (12h/)	flufenacet	X	X				X		X			Not for sensitive varieties.
Dual (II) Magnum* (12h/-)	s-metolachlor	X	X			X	X		X	X		Premixes with atrazine are available
Gramoxone Inteon* (12h to 24h/-)	paraquat	X	X			X		X	X	X	X	
Impact*, others	topramazone				X			X		X	X	
Laudis* (12h/-)	tembotrione				X			X		X	X	
Lexar* (12h/-)	s-metolachlor, mesotrione, atrazine	X	X				X	X	X	X	X	
Lumax* (12h/-)	s-metolachlor, mesotrione, atrazine	X	X				X	X	X	X	X	
Outlook*, others (12h/50d)	dimethenamid-P	X	X		X		X		X	X		Premixes with atrazine are available
pendimethalin products (12h/ -)	pendimethalin		X		X		X		X	X		
Roundup*, others (12h/7d)	glyphosate	X	X			X		X	X	X	X	
Sandea*, others (12h/30d)	halosulfuron			X		X	X	X		X	X	Effective against nutsedge
Starane* (12h/31d)	fluroxypyr				X	X		X		X	X	Controls volunteer potato
Stinger* (12h/30d)	clopyralid				X			X		X	X	
Zidua* (12h/37d)	pyroxasulfone	X	X		X		X		X	X		

[1]For effectiveness against specific weeds, see Table 26 on page 61, and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbcides can cause serious crop injury and yield loss if not used properly.

[2]X=permitted on label. Defined crop stage varies by herbicide.

Insect Control

Seedcorn Maggots, Seedcorn Beetles, Wireworms

Plant seed that has been treated with an insecticide prior to planting. Use diazinon, Cruiser®, or Poncho®. Follow label directions.

Although most sweet corn seed has been treated with a fungicide, it is seldom treated with an insecticide to prevent seed and seedling damage.

Recommended Products

Brigade 2EC® at 0.15-0.3 fl. oz. per 1,000 linear ft. of row. Apply in furrow or T-band. May be applied in conjunction with pop-up fertilizers. Also controls cutworms and grubs. Do not exceed 0.1 lb. a.i. per acre per season at plant application. 30-day PHI.

Capture LFR® at 0.2-0.39 fl. oz. per 1,000 linear ft. of row at planting. See label. *RUP*.

Force CS® at 0.46-0.57 fl. oz. per 1,000 linear ft. of row at planting. See label. *RUP*.

Corn Rootworm Larvae

Recommended Products

Aztec 2.1G® at 6.7 oz. per 1,000 linear ft. of row. Apply in a 7-inch band over the row and behind the planter shoe in front of the press wheel.

Brigade 2EC® at 0.3 fl. oz. per 1,000 linear ft. of row. Apply in a minimum of 3 gals. of finished spray as a 5-7 inch band over an open seed furrow (T-band). Do not exceed 0.1 lb. a.i. per acre per season at plant application. 30-day PHI.

Capture LFR® at 0.39-0.49 fl. oz. per 1,000 linear ft. of row at planting. See label. *RUP*.

Counter 15G® at 6-8 oz. per 1,000 linear ft. of row. If few or no rootworm beetles were present in the field the previous year, then there is little chance of a damaging infestation. If sweet corn was grown in the field the previous year and a regular spray schedule was followed during silking, then there is little chance of a damaging infestation. Do not exceed 1 application per acre per crop.

Force 3G® at 4-5 oz. per 1,000 linear ft. of row. Apply as a T-band or in furrow. Do not exceed 1 application per crop.

Force CS® at 0.46-0.57 fl. oz. per 1,000 linear ft. of row at planting. See label. *RUP*.

Lorsban 15G® at 8 oz. per 1,000 linear ft. of row. If few or no rootworm beetles were present in the field the previous year, then there is little chance of a damaging infestation. If sweet corn was grown in the field the previous year and a regular spray schedule was followed during silking, then there is little chance of a damaging infestation. Do not exceed 13 lbs. per acre per crop.

Mocap 15G® at 8 oz. per 1,000 linear ft. of row. Do not exceed 1 application per acre per crop. Do not place in the furrow or in direct contact with the seed.

Thimet 20G® at 4.5-6 oz. per 1,000 linear ft. of row.

Warrior II® at 0.33 oz. per 1,000 linear ft. of row. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Corn Leaf Aphid

Heavy corn leaf aphid infestations are often limited to early-season plantings that develop on late whorl to early-tassel sweet corn. During this time, several beneficial organisms (including lady beetles, minute pirate bugs, and parasitoids) will keep these infestations in check.

Although infestations can exceed 100 aphids per plant on more than 50% of the plants, pollination is rarely affected. Fresh market growers may need to spray to avoid aphid colonies on the husks or sticky honeydew (excreted by aphids) on the husks. Choose products that will control both caterpillar pests (corn earworm, European corn borer, fall armyworm) and aphids if both are a problem.

Recommended Products

Lannate SP® at 0.25-0.5 lb. per acre. Do not exceed 6.3 lbs. a.i. per acre per crop. 0-day PHI for ears. 3-day PHI for forage.

Corn Rootworm Adults

Most of the insecticides listed below for control of European corn borer, corn earworm, and armyworms also control corn rootworm beetles. Those that do not control corn rootworm beetles are Belt®, Coragen®, Entrust®, Intrepid®, Radiant®, and SpinTor®.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.

Cutworms

Recommended Products

Ambush 25W® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 1-day PHI.

Baythroid 2E® at 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI.

Lorsban 4E® at 1-2 pts. per acre. Most effective when soil is moist. If ground is dry, cloddy, or crusty, shallow incorporation before (or soon after) treatment may improve control. 35-day PHI.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP*.

European Corn Borer, Corn Earworm, Fall Armyworm

European Corn Borer Threshold

More than 10 moths per night in a black light traps while corn is in late whorl stage.

Corn Earworm Threshold

More than 10 moths per night in pheromone traps while green silks are present.

Fall Armyworm Threshold

Moths being caught in pheromone traps or larval damage present while corn is in late whorl stage.

Recommended Products

Ambush 25W® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. a.i. per acre per season. Control is poor when temperatures are above 90°F. 1-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. *Corn earworm only*. Do not exceed 96 fl. oz. per acre per season. 1-day PHI.

Baythroid 2E® at 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI.

Belt SC® at 2-3 fl. oz. per acre. Do not exceed 12 fl. oz. per acre per season. 1-day PHI.

Besiege® at 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. 1-day PHI. *RUP.*

Blackhawk® at 1.67-3.3 oz. per acre. 1-day PHI.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI.

RR **Coragen**® at 3.5-5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Entrust® at 0.5-2 oz. per acre. More effective for European corn borers than corn earworms. Do not exceed 9 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

RR **Intrepid 2F**® at 4-16 fl. oz. per acre. *European corn borer only*. Do not exceed 64 fl. oz. per acre per season. 3-day PHI.

Lannate SP® at 0.25-0.5 lb. per acre. *European corn borer only*. Do not exceed 7 lbs. per acre per crop. 0-day PHI for ears. 3-day PHI for forage.

Larvin 3.2® at 20-30 fl. oz. per acre. Do not exceed 300 fl. oz. per acre per season. 0-day PHI.

Mustang MAX® at 2.8-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. Control is poor when temperatures are above 90°F. 1-day PHI.

RR **Radiant SC**® at 3-6 fl. oz. per acre. Do not exceed 6 applications per season. 1-day PHI.

Sevin XLR PLUS® at 1.5-2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. 2-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP*.

Monitoring European Corn Borer and Corn Earworm

One of the keys to successfully managing European corn borers and corn earworms on sweet corn is to determine when the insects are active. European corn borers can be monitored effectively with blacklight traps and field observations, and corn earworms can be monitored with pheromone traps. When moths are being caught in the traps, it means they are laying eggs.

Corn borer eggs are laid on leaves, usually on the undersides, in the region of the ear. Larvae feed on the leaves and later may migrate to the ears (if present).

Corn earworm moths lay their eggs directly on green silks. The larvae that hatch from those eggs will follow the silks down into the tips of the ears.

Because these two insects' egg laying behavior differ, control strategies also differ. Corn borers can be controlled by spraying during the late whorl, tasselling, and silking stages. The migrating larvae should contact a lethal dose of insecticide while moving to the ear zone. Corn earworms must be controlled by directing sprays at the silks so larvae will immediately contact the insecticide after hatching.

For corn borers, treat during the late whorl stage if 20 percent or more of the plants show larval feeding. The presence of

RR This is a reduced-risk pesticide. See page 34 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

large numbers of moths in light traps also justifies treatment. One application during the late whorl stage, followed by additional treatments every five days up until seven days of harvest, usually provides adequate control.

For corn earworms, treatment is justified if fresh green silks are present and moths are being caught in pheromone traps. In general, the higher the moth catches, the shorter the interval between sprays. If fewer than five moths are being caught per night, a five-day spray interval should be adequate. As moth catches approach 50 to 100 per night, a two- to three-day spray interval would be more appropriate. Determining the spray interval exactly depends on many factors, including how much damage you can tolerate, the crop's value, and the cost and effectiveness of the insecticide. Stop treating for corn earworms when 90 percent of the silks are brown.

Obviously, growers should not treat separately for these two pests. Some of the insecticides recommended here are effective against both species. Choose insecticides that are more effective against the particular pest that is most prevalent at the time of application. If both pests are present, choose an insecticide that will adequately control both.

Sources of Corn Earworm and European Corn Borer Traps

Bob Poppe's Service
25738 N. 3200 East
Lexington, IL 61753
(309) 275-5477

Sources of Pheromones/Traps

Gempler's
P.O. Box 270
100 Countryside Drive
Belleville, WI 53508
(800) 382-8473
www.gemplers.com

Great Lakes IPM
10220 Church Road
Vestaburg, MI 48891-9746
(989) 268-5693
www.greatlakesipm.com

Insects Limited Inc.
16950 Westfield Park Road
Westfield, IN 46074-9374
(317) 896-9300
www.insectslimited.com

Pacific Biocontrol Corporation
620 E. Bird Lane
Litchfield Park, AZ 85340
(623) 935-0512 or (800) 999-8805
www.pacificbiocontrol.com

Scentry Biologicals, Inc.
610 Central Avenue
Billings, MT 59102
(800) 735-5323
www.scentry.com

Trece Incorporated
PO Box 129
Adair, OK 74330
(866) 785-1313
www.trece.com

Flea Beetles

Plant varieties that are resistant to Stewart's wilt, which is vectored by flea beetles.

Recommended Products

Ambush 25W® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI.

Asana XL® at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 1-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI.

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI.

Lannate SP® at 0.25-0.5 lb. per acre. Do not exceed 7 lbs. per acre per crop. 0-day PHI for ears. 3-day PHI for forage.

Lorsban 4E® at 1-2 pts. per acre. Do not exceed 15 pts. per acre per crop. 21-day PHI.

Mustang MAX® at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI.

Sevin XLR PLUS® at 1-2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. 2-day PHI.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP*.

Stink Bugs (including Brown Marmorated Stink Bug)

Brigade 2EC® at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI.

Hero® at 4-10.3 fl. oz. per acre. 3-day PHI.

Sweet Potato

Varieties	
Beauregard	Early, light red skin, orange flesh, increasingly popular
Centennial	Soft-fleshed type, orange skin
Covington	Orange-fleshed, smooth-skinned, rose-colored, 5-10 days later than Beauregard. Resistant to Fusarium wilt, southern root-knot nematode, and moderately resistant to streptomyces soil rot.
Hernandez	Copper skin, deep orange flesh
Julian	Deep orange, good quality (same as Centennial)
Nugget	Firm-fleshed type, orange skin, orange flesh, good quality, excellent keeper
For Trial	
Carolina Ruby	Dark red skin, orange flesh

Plant Production

Select seed stock from high-yielding hills that are smooth, well-shaped, and free of diseases (scurf, internal cork, wilt, black rot) and insect injury. Where internal cork is present, obtain seed stock from suppliers who have cork-free stock. Store seed stock in new crates to avoid disease contamination. Seed potatoes should be at least 1.5 inches in diameter. One bushel of small- to medium-sized roots should produce 2,000 to 2,500 plants (slips) from three pullings.

Treating seed before planting with Mertect 340-F® will protect roots from infection by certain disease-causing organisms. Bed the seed stock in new, clean sand taken from upland banks or pits. Allow 10 to 12 square feet of bed area per bushel of seed. Maintain plant bed temperature at 75°F to 85˚F.

Planting and Spacing

Transplanting machines are available for mechanically planting sweet potato slips. Common spacing is 1 foot apart in the row, with rows 3 to 4 feet apart, depending upon the cultivating and harvesting equipment used. 14,520 slips per acre are required at the 1 foot by 3 feet spacing, while 10,890 are needed at the 1 foot by 4 feet spacing. Transplant only strong, stocky slips. Yields can be increased up to 100 bushels per acre by using strong transplants.

Fertilizing

Lime: None usually necessary. Soil pH of 5.0 to 6.0 is satisfactory.

Preplant: N: 30 pounds per acre. P_2O_5: 0 to 75 pounds per acre. K_2O: 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Set the slips with a starter solution at the rate of 1 cup (8 ounces) per plant.

Sidedress N: None usually necessary on finer textured soils. On irrigated sands, sidedress with 30 to 50 pounds N per acre approximately 3 to 4 weeks after transplanting.

Harvesting

Remove vines by cutting with a rotary mower. Dig only those potatoes that can be picked up immediately and not left out overnight. Temperatures below 50˚F can chill potatoes and cause internal breakdown in storage. Potatoes will sunburn if left in direct sunlight for more than an hour. Field grading is important.

Prevent skinning and breaking. Use cotton gloves when placing potatoes in crates. Place well-shaped No. 1's with No. 2's, and cuts with culls.

Storing

When the storage house is filled, raise the temperature to 85˚F. Keep it at this temperature for 6 to 8 days, with 85 percent to 90 percent humidity for proper curing. After curing, the temperature may be gradually dropped to 55˚F. Hold this temperature until potatoes are marketed or used for producing slips.

Disease Control

Black Rot, Foot Rot, Fusarium Wilt, and Scurf

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

Recommended Products

Botran 75W® or **Botran 5F®** as a seed dip or plant bed spray. *Scurf only*.

Mertect 340F® at 8 fl. oz. per 7.5 gals. Of water. *Not for Fusarium wilt*.

Storage Rots

Fumigate storage boxes. Cure and store only healthy, blemish-free tubers.

Weed Control

Sweet potatoes are often grown on black plastic mulch because they benefit from the higher soil temperature it provides early in the season. The mulch also provides weed control near the row. Between rows, cultivation and hand hoeing are typically used until the sweet potato vines cover the soil. A few herbicides are available for use in sweet potato.

For specific weeds controlled by each herbicide, check Table 26 on page 61.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Burndown or Directed/Shielded Applications Broadleaves and Grasses

Recommended Products

RR **Glyphosate** products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations of 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before planting, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at 1.3-4 pts. per acre. Use low rate on coarse soils. Apply before planting, or apply up to 1.5 pts. per acre after transplanting and before weeds emerge. 95-day PHI for rates up to 3.3 pts. per acre. 125-day PHI for rates more than 3.3 pts. per acre.

Preemergence Broadleaves

Recommended Products

Valor SX® at 2 oz. per acre. Apply 2-5 days before transplanting. Do not use on greenhouse-grown transplants, or on transplants harvested more than 2 days before transplanting. Do not use on varieties other than 'Beauregard' unless you have tested for phytotoxicity under your conditions. Do not exceed 2.5 oz. per acre per growing season.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or **Dacthal Flowable**® at 6-14 pts. per acre. Apply at transplanting or layby. May be applied over the top of transplants.

Postemergence Broadleaves and Grasses

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves

Recommended Products

Aim EC® at 0.5-2 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season.

Postemergence Grasses

Recommended Products

Fusilade DX 2E® at 10-12 fl. oz. per acre. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Apply to actively growing grass. Do not exceed 48 fl. oz. per acre per season. 55-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 5 pts. per acre per year. 30-day PHI.

Select Max® at 12-32 fl. oz per acre, or **Select 2EC**® at 6-16 fl. oz. per acre. Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 64 fl. oz. of Select Max®, or 32 fl. oz. of Select 2EC® per acre per season. 30-day PHI.

RR This is a reduced-risk pesticide. See page 34 for details.

Insect Control

Aphids

Recommended Products

RR **Actara**® at 3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 125-day PHI.

Foliar applications: 1.2 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. or 1 application per acre per season.

RR **Assail 30SG**® at 2.5-4 oz. per acre. 7-day PHI.

Belay 2.13SC® at 2-3 fl. oz. per acre. 14-day PHI.

RR **Fulfill**® at 2.75-5.50 oz. per acre. 14-day PHI.

RR **Movento**® at 4-5 fl. oz. per acre. 7-day PHI.

RR **Platinum**® at 5-8 fl. oz. per acre. Apply at planting.

Colorado Potato Beetles

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.

RR **Assail 30SG**® at 0.6-1.7 oz. per acre. 7-day PHI.

Avaunt® at 3.5-6 oz. per acre. 7-day PHI.

Baythroid® at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Entrust® at 1-2 oz. per acre. 7-day PHI.

Mustang Max® at 3.2-4 fl. oz. per acre. 1-day PHI.

RR **Radiant SC**® at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. or 2 applications per acre per season.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Potato Leafhoppers

Recommended Products

RR **Actara**® at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. 14-day PHI.

Admire PRO® at the following rates:

Soil applications: 4.4-10.5 fl. oz. per acre. 125-day PHI.

Foliar applications: 1.2 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. or 1 application per acre per season.

RR **Assail 30SG**® at 1.5-4 oz. per acre. 7-day PHI.

Baythroid® at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl oz. per acre per season. 0-day PHI. *RUP*.

Mustang MAX® at 3.2-4 fl. oz. per acre. 1-day PHI.

RR **Platinum**® at 5-8 fl. oz. per acre. Apply at planting.

Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. *RUP*.

Wireworms, Flea Beetle Larvae

Recommended Products

Baythroid® at 1.6-2.8 fl. oz. per acre. *Flea beetles only*. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. *RUP*.

Brigade 2EC® at 9.0-19.2 fl. oz. per acre at planting. 21-day PHI.

Capture LFR® at 12.75-25.5 fl. oz. per acre. *Apply at planting or layby.*

Lorsban 15G® at 13.5 lbs. per acre Evenly distribute granules over treated area. After application, incorporate to a depth of 4-6 inches by rotary hoe or disc cultivator. Do not exceed 1 application per season. 125-day PHI.

Lorsban 4E® at 4 pts. per acre, or **Lorsban 75WG**® at 2.67 lbs. per acre. Apply to soil surface as a preplant broadcast spray. Incorporate immediately after application to a depth of 4-6 inches. Plant sweet potatoes no more than 14 days after treatment. Do not exceed 1 application per season. 125-day PHI.

RR **Platinum**® at 5-8 fl. oz. per acre. *Seed treatment only*. Apply at planting.

RR This is a reduced-risk pesticide. See page 34 for details.

Calibration of Application Equipment

Rate of application, granular and sprays, may vary with materials used. Equipment must be calibrated for each material applied to obtain accurate delivery. Here are suggested steps to calibrating three types of applicators.

Boom Sprayer

1. Clean sprayer, and replace all worn or defective parts; fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray 1/4 acre (10,890 sq. ft.). Distance of travel will vary with boom width.

For example, a 22 ft. boom must travel 495 ft. to cover 1/4 acre:

$$\frac{\text{1/4 acre (10,890 sq. ft.)}}{\text{Boom width (22 ft.)}} = \text{distance of travel (495 ft.)}$$

4. Measure amount of water needed to refill the tank. This amount was applied to the 1/4 acre; thus, four times this amount is the gallonage per acre.
5. Adjustment in gallonage may be made either by varying tractor speed or by changing nozzle size. Recalibrate after making an adjustment.
6. Calculate acres covered by tank of spray solution, and add required amount of pesticide for total area sprayed.

Band Sprayer

1. Clean sprayer, and replace all worn or defective parts; fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray 1/4 acre (10,890 sq. ft.). Distance traveled will vary with number of nozzles on the sprayer and width of the band sprayed by each nozzle.

For example, spraying a 20-inch band over 4 rows using 1 nozzle per row requires 1630 ft. to cover 1/4 acre:

$$\frac{\textit{¼ acre (10,890 sq. ft.)}}{\text{Nozzles (4) x spray band width (1.67 ft.)}} = \frac{\text{10,890 sq. ft.}}{\text{6.68 ft.}} = \text{distance of travel (1630 ft.)}$$

Measure amount of water needed to refill the tank. This amount was applied to the 1/4 acre; thus, four times this amount is the gallonage per acre.

4. Adjustment in gallonage may be made either by varying tractor speed or by changing nozzle size. Recalibrate after making an adjustment.

5. Calculate acres covered by tank of spray solution, and add required amount of pesticide for total actual area to be band treated.

Granular Band Applicator

1. Set applicator dial or dials to give desired delivery rate of granules suggested for band treatment according to manufacturer's instructions.
2. Fill hoppers with granules to be used.
3. Travel across field at planting speed for the distance required to cover 1/16 acre (2,722 sq. ft.) per row. Collect granules for each row in a bag, bucket, or other container.

For example: granular band application for a 40-inch row requires 817 ft. to cover 1/16 acre:

$$\frac{\text{1/16 acre (2,722 sq. ft.)}}{\text{Row width (3.33 ft.)}} = \text{distance to travel (817 ft.)}$$

Weigh granules from each row separately, and multiply by 16 to find delivery per acre for each row.

4. Adjust each setting, and recalibrate until the desired delivery rate is obtained.

Pesticide Application Record[1] and Written Notification for EPA Worker Protection Standards[2]

Business Name														
Location	**Pesticide**					**Application**								
Field	Crop	Product Brand Name & Chemical Formulation[3]	Active Ingredient	Name of Manufacturer	EPA Registration Number	Pest Controlled	Area Treated (Sq. ft. or Acres)	Pesticide Rate	Total Amount of Pesticides Used	Name & Certification No. of Applicator or Certified Supervisor	Date (Mo./Day/ Year)	Time	Restricted Entry Interval (hrs.)	OK to Enter (Date & Time)

[1]Information required by Federal and State Recordkeeping Requirements for Certified Applicators of Federally Restricted Use Pesticides (RUP). Records for restricted use pesticides must be maintained for two years from date of pesticide application.

[2]For EPA Worker Protection Standard, information in shaded columns must be recorded for all pesticides and be maintained at the centrally located posting area for 30 days after the restricted entry interval expires.

[3]Formulation required if included in product name: DF=dry flowable, EC & E=emulsifiable concentrate, G=granules, F=flowable, L=liquid, S=soluble, ULV=ultra low volume, etc.

This form was prepared by a joint effort of the Northwest Horticulture Program, Department of Horticulture and Landscape Architecture, and Purdue Pesticide Programs, Purdue University.

Figure 1. (Left) Bacterial spot of tomato causes small necrotic lesions on leaves that are often accompanied by chlorosis. (Right) Lesions on fruit are often scabby in appearance. See page 126 for management options.

Figure 2. Bacterial spot lesions on pumpkin are light colored with water-soaked margins. The cut open pumpkin shown here has a secondarily infected lesion that has rotted through the fruit. See page 95 for management options.

Figure 3. Gummy stem blight on watermelon often turns leaf petioles light brown and produces dark brown, irregular leaf lesions. See page 107 for management options.

Figure 4. (Left) Downy mildew of cucumber causes angular chlorotic lesions. (Right) During moist conditions, the fungus that causes downy mildew is visible on the undersides of infected leaves. See page 106 for management options.

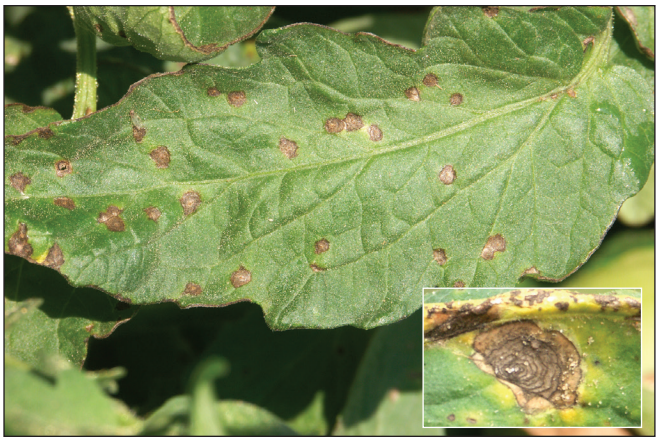

Figure 5. Early blight is one of the most common tomato diseases. The inset shows a close-up of early blight's characteristic bull's-eye lesions. See pages 127-128 for management options.

Figure 6. White mold or timber rot of tomato kills stems and entire plants. The black fungal structures (sclerotia) shown here are diagnostic of this disease. See page 129 for management options.

Figure 7. European corn borers can be a problem in peppers. See pages 135-136 for management options.

Figure 8. Seedcorn maggots can be a problem in many crops including cantaloupe. See page 114 for management options.

Figure 9. Colorado potato beetles can be a pest in many crops, including eggplant. See page 134 for management options.

Figure 10. The brown marmorated stink bug is an emerging pest in the Midwest. If you see this pest, contact your state extension specialist. More information is available from Purdue Extension at extension.entm.purdue.edu/caps/pestInfo/brownStinkBug.htm. Control information is provided for Fruiting Vegetables (page 136) and Sweet Corn (page 200).

Figure 11. Corn earworm larva (left) can be a significant sweet corn pest. The adult (right) is shown for identification purposes. See page 199 for management options.

Figure 12. Indiana has confirmed the presence of western bean cutworm and it may be present in other states covered by this guide. It is not clear how much damage this pest causes. If you observe this pest, contact your state extension specialist.

Figure 13. Manganese toxicity on cantaloupe is a disorder that can occur if soil pH is too low. See page 103 for soil pH and fertility recommendations for cucumber, cantaloupe, and watermelon.

Figure 14. Sunscald appears as a white, hard area on a portion of the tomato fruit. The area may later shrivel and sink in. See page 118 for details.

Figure 15. Tomato pinworm *(Keiferia lycopersicella)* is an emerging pest in the Midwest. See pages 135-136 for management options.

Figure 16. Radial (left) and concentric cracks on tomato. See page 118 for more information.

Figure 17. Zipper scars on tomatoes. See page 118 for more information.

Figure 18. Catfacing on tomato. See page 118 for more information.

Figure 19. Micro-cracks or rain checks. See page 118 for more information.

Figure 20. These roma tomatoes suffer from varying degrees of blossom end rot. See page 119 for management options.

Pesticide Emergency and Poison Control Centers

Nationwide Emergency Number

(800) 222-1222
This number will automatically connect you to the poison center nearest you.

Illinois

Illinois Poison Center
222 S. Riverside Plaza, Suite 1900
Chicago, IL 60606

Emergency Number: (800) 222-1222
TDD/TTY: (312) 906-6185
www.mchc.org/ipc

Personnel at this number will give first aid instructions and direct callers to local treatment centers.

For immediate emergency treatment or ambulance service, always call 911.

Indiana

Indiana Poison Center
Methodist Hospital, Clarian Health Partners
Interstate 65 at 21st Street
Indianapolis, IN 46206-1367

Emergency Number: (800) 222-1222
TTY/TDD: (317) 962-2336
Fax: (317) 962-2337
indianapoison.org

Iowa

Iowa Statewide Poison Control Center
401 Douglas St., Suite 402
Sioux City, IA 51101

Emergency Number: (800) 222-1222
To Report Spills: (515) 281-8694
(also contact local law enforcement)
TTY: (800) 222-1222
www.iowapoison.org

Kansas

Mid-America Poison Control Center
University of Kansas Medical Center
B400 KU Hospital
3901 Rainbow Boulevard
Kansas City, KS 66160-7231

Emergency Number: (800) 222-1222
Kansas City Residents May Phone: (913) 588-6633
Emergency TDD: (913) 588-6639
www.kumed.com/poison

Minnesota

Minnesota Poison Control System
Hennepin County Medical Center
701 Park Avenue, Mail Code RL
Minneapolis, MN 55415

Emergency Number: (800) 222-1222
Local Number: (612) 873-3141
TTY: (800) 222-1222
www.mnpoison.org

Missouri

Missouri Regional Poison Center
7980 Clayton Road, Suite 200
St. Louis, MO 63117

Emergency Number: (800) 222-1222
In St. Louis: (314) 772-5200
TDD/TTY: (314) 612-5705

Ohio

Ohio Poison Exposure Centers

Emergency Number: (800) 222-1222
TDD: (800) 253-7955
All calls will be automatically routed to the regional Ohio Poison Exposure Center closest to you.

Extension Vegetable Crop Production Websites

Midwest Vegetable Production Guide for Commercial Growers
mwveguide.org

Illinois Fruit & Vegetable News
www.ipm.uiuc.edu/ifvn

Iowa State University
www.extension.iastate.edu/vegetablelab

K-State Plant Pathology Extension
www.plantpath.k-state.edu/p.aspx?tabid=49

K-State Horticulture Extension
www.hfrr.ksu.edu/p.aspx?tabid=931

Minnesota VegEdge
www.vegedge.umn.edu

Ohio VegNet
vegnet.osu.edu

Purdue Fruit and Vegetable Connection
www.hort.purdue.edu/fruitveg

Radcliffe's IPM World Textbook
ipmworld.umn.edu

University of Missouri
www.plantsci.missouri.edu